THE

# ENGINEERING MAGAZINE

VOL. III. AUGUST, 1892. No. 5.

## COMPRESSED AIR FOR STREET-CARS.

*By General Herman Haupt, C. E.*

IN view of the objections to the overhead electric system for propulsion of cars on surface roads in cities, the annoyance from tearing up streets and the cost of plant and maintenance of the cable lines, the expense of horse power, with the sanitary evils resulting from the location of stables in populous cities, the fact that pneumatic motors, after a successful demonstration of their superiority, have been largely overlooked seems inexplicable. These motors not only are entirely free from the objectionable features of the other systems, but they furnish a mode of propulsion which is more safe and more economical than any other with equal velocity of transit. These assertions are made advisedly and are based on actual demonstration.

In 1878 and 1879 five pneumatic motors were constructed upon the plans and under the supervision of James Hardie, Mechanical Engineer, and were run for several months on the Second-avenue railroad in New York with perfect success. In 1879 the writer was called upon in the interest of proposed investors to investigate and report upon the practicability and expediency of using pneumatic power for street railroads. The comparative results were overwhelmingly in favor of motors of this class, but all attempts to secure their general introduction at that time proved failures.

The position taken by the officers of horse-railroad companies, both in New York and Philadelphia, was that any car running along city streets without horses in front would frighten horses, cause runaway accidents and subject companies to suits for damages. This objection of course applies with much greater force to the

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cable and trolley systems, which are accompanied by a loud humming noise, while the pneumatic motor can have a noiseless exhaust; but no argument or explanation availed in the face of this senseless objection. One railroad president declared that if the motor were adopted by his company it would be necessary to kill some of his old horses, stuff the skins and mount a pair of them on a low truck in front of each car!

The attempt to introduce pneumatic motors was thus found to be premature in 1879. The company could make no progress and finally abandoned all effort, losing the capital expended in plant and demonstration, and no attempt to revive the motor has since been made. But the engineer and inventor, Robert Hardie, now in the service of the mechanical department of the Columbian Exposition at Chicago, retains unshaken confidence in the superiority of the pneumatic motor.

Conditions existing now seem favorable for the introduction of a motor which, free from the objections to all other systems, with no new defects of its own, may be considered as perfect. No fears are now entertained that a car running without horses in front will make a stampede of all equines on the streets traversed, and this in 1879 was the only reason urged in opposition to the introduction of the pneumatic motor. It is possible, therefore, that a few extracts from the report made in 1879 may be of interest at this time.

The compression-plant was located in Harlem in New York, on the line of the Second-avenue railroad. It developed 66 horse-power and charged the cylinders under a car with compressed air in seven minutes. With proportionately larger plant not more than one minute would be required. The report of Mr. Hardie stated the capacity of the cylinders under the seats at 17,000,000 foot-pounds of work, capable of running a car sixteen miles on a level. The effect of the compressed air was greatly increased by passing it through a tank of hot water at the temperature due to 80 pounds pressure. The tank had a capacity of five cubic feet and was placed on the side of the platform.

The writer has not at hand a copy of his full detailed report, but only an abstract of some of the results, which will be given here.

A duty of nearly 50 per cent. of the horse-power used in compressing air can be secured from the expansion and utilization of dry air when compressed; and, by using stationary, compound or condensing engines, four times the power can be obtained with a given cost of fuel, as compared with ordinary steam-motors, which

more than counterbalances the loss in compression. By the addition of a heater and passing the air through hot water an increase of nearly 100 per cent. power can be secured at a merely nominal cost.

On a straight and level road, with 160 cubic feet of air in the reservoirs, under an initial pressure of 350 pounds, the motor would run seven miles with a reserve of one-third left in the reservoirs on its return. This result assumes that the amount of air expended at each stroke is equal to a full cylinder of air expanded to atmospheric tension, but actual work has demonstrated an ability to run ten miles with a single charge, proving that less than this quantity is sufficient. The back pressure which would result from working against a vacuum is relieved by suction valves in the exhaust passages.

In descending grades the motor cylinders act not only as brakes, but also as air-pumps, and have power to pump back into the reservoirs, against a pressure of 200 pounds, sufficient air to raise the gage-pressure seven pounds in running 2100 feet, and restore sufficient air, when heated, to run the motor half that distance upon a level. By this remarkable contrivance power can be stored on descending grades. The down-hill portions not only use no power, but give back a portion of that which was expended in ascending.

The compressed air can be used expansively to any extent, and cut off at any part of the stroke. It can act as a brake, or the motor can be instantly reversed, and the braking apparatus is exceptionally complete and satisfactory.

The power of an eight-ton motor is sufficient to propel three cars on a straight and level road. With full power in the motor cylinders and full adhesion on the rails the motor can overcome grades of 300 feet to the mile.

Although, during a run, the pressure in the reservoirs is constantly diminishing, yet, by means of a reducing valve, the working pressure in the motor cylinders is maintained at a constant limit.

Each motor, allowing for increased speed, would take the place of ten or fifteen horses, the cost of which would about equal the cost of the motor, $1500.

The system would be particularly adapted to suburban localities and would afford better facilities for rapid transit than are now afforded by elevated roads, for while the speed would be equal to

twenty miles or more per hour, the stops need not be limited to stations, but could be made at any point.

With the small class of motors, three cars, or two in addition to the motor, can ascend grades as steep as any usually found on horse railroads. This is a point of the greatest value for public accommodation. It will enable a company to utilize all its old cars and supply additional cars at the hours when the rush of travel requires them without additional expense for power or conductors.

The Delamater Iron Works offered to supply a compression plant of sufficient capacity to charge one car per minute for $20,000.

Compressed air can be transmitted to any distance without loss except for friction in pipes. If pipes are large and velocity low the loss will be inconsiderable. Several lines could therefore be operated from a large central plant and in many localities natural water-powers could be utilized to compress air and the compressed air transmitted by pipes to charge motors, generate electric currents, or drive machinery by direct application to cylinders.

To charge motors at a central station a nozzle between the tracks and a short piece of pressure-hose to screw on to the air reservoir is all that would be required to connect with reservoirs located in a building. It would not be necessary to run the cars into a house to renew the air-supplies.

The running expenses are less than one-half—in fact, the estimate shows less than one-third—the cost of horse power. The motors run without noise, ashes or smoke, are perfectly under control and would furnish the best possible power to operate elevated railroads. Skilled engineers are not required. An ordinary car-driver can be taught to run an engine in a single trip.

No flues can be burned or boilers exploded though carelessness, and as air-reservoirs last indefinitely, explosions in transit from causes which render steam dangerous are impossible. Even if an explosion should occur by a rupture it would be while charging the reservoir at the time of maximum pressure and not in transit, and the air would simply escape with a hissing sound ; cold, not heat, would result from the expansion.

The car acts as its own governor and no more air can be used than is necessary to overcome the resistance ; there can be no waste. There are no horses in front to obstruct a clear view of the track. At a speed of twelve miles per hour the motor can be stopped on a

level within its length, and the braking apparatus cannot get out of order so long as the motor can move at all.

The pneumatic motor would be peculiarly adapted to underground roads, as the escape of pure air would assist in the ventilation, but it is the best possible for all urban or suburban roads, whether elevated, surface or in tunnels.

In this paper results only have been given, but the full report made in 1879 gives the facts upon which the conclusions have been based.

A detailed estimate was made from data furnished by the operations of the Second-avenue railroad and a comparison of cost of operation by horse power and by the pneumatic motor. In this estimate it was assumed that a compression plant was located at each end of the route, requiring double the expenditure for plant and double the expense of operation over a single plant located in the middle of the run, which would answer just as well. The estimate for pneumatic power was designedly made in excess, so that errors would be on the safe side, and the cost of horse power was from actual results on the Second-avenue railroad.

On the basis of 16,000,000 passengers carried on this road in 1878, the year previous to the report, the actual results of operation by horse power were:

| | |
|---|---|
| Running expenses per passenger in cents | 2.88 |
| Estimate by pneumatic motor | 0.93 |
| Cost per passenger by horse power, including general expenses and a six per cent. dividend | 4.55 |
| Estimate by use of pneumatic motor | 2.57 |

The dividend was $72,000=0.45 cents per passenger.

The conclusion from the data furnished was that a very small increase in the number of passengers would permit the company to sell ten tickets for 25 cents and still pay fair dividends upon the capital invested, besides furnishing a rapid transit the speed of which would be limited only by considerations of safety.

But all these demonstrations and representations, backed by the very strongest indorsements of the daily press in New York and by the actual running of five motors daily for a period of several months, availed nothing against the senseless cry, "It will scare horses," or, "The motor cannot be run unless we put stuffed horses in front of each car." It is true that horses on the opposite track did at first prick up their ears, look at the motor and shy a little,

but they never gave any trouble and soon became accustomed to it, and no case of a runaway accident with street vehicles was heard of, but prejudice, which proved all powerful to exclude the pneumatic motor at that time, did not prevent the introduction of the trolley and cable systems very soon afterwards.

# MORE OF THE MISSISSIPPI PROBLEM.

## I.—THE LEVEES INDISPENSABLE.

*By Chauncey N. Dutton.*

IT is evident that the writers of two recent articles in this magazine touching upon the improvement of the Mississippi river—Mr. William Nelson Black and "A Southern Engineer"—have jumped at conclusions in a very reckless way. A careful study of the phenomena of the Mississippi plainly shows certain facts, among them these:

Unless the levees below Natchez are maintained the greater part of Louisiana must be abandoned and revert to trackless swamps.

Every division of the current of the Mississippi has been an evil unmixed with good. Every outlet has worked injury, caused deterioration of the main channel and increased the height of the flood wave and its dangers.

No good and permanent improvement of the lower reaches of the Mississippi is possible without the use of artificial banks—levees and jetties—which shall safely confine *all* the water of the river to one channel and discharge it into the gulf by one narrow deep mouth upon the line of least resistance. The guiding principle announced by the Mississippi River Commission, that the river must be confined to one narrow channel, is most undoubtedly correct.

ANCIENTLY the edge of this continent was about where the five-fathom curve now lies in the Gulf of Mexico, and the Mississippi flowed in a bed now buried many feet under the alluvium. A cataclysm depressed the continent so that the coast retreated to what are now the high lands, and the Mississippi found its mouth at or near Cairo, Illinois, the present alluvial valley being the bottom of a great estuary extending some 600 miles into the continent. During this period the alluvium (loess) of the valley was deposited on the floor of the estuary. A succeeding cataclysm raised the continent so that its ancient edge is but five fathoms or thereabouts below the gulf level, and the floor of the great estuary is a wide alluvial plain, having a fall from Cairo to the Gulf of about six inches to the mile. This fall being so slight, the whole structure of the alluvial ground so featureless and so unstable, and the discharge of

the river so vast and so irregular—varying from 160,000 to 1,800,000 cubic feet per second and reaching a total of 202 cubic miles per year—the required conditions of regimen and stability of channel must be made by art.

Examination of the country shows that the river has curved its channel from one side to the other of the alluvial plain and has nowhere found conditions of stability except where man has aided by building levees, and that where the levees have been built longest and strongest and best maintained, there the channel is deepest, most regular and least liable to change. On the other hand, wherever crevasses and outlets have occurred, the channel has been shoaled up, the banks have been destroyed and the dangers from erosion and from flood increased. The most startling of these changes is that due to the Atchafalaya outlet, the progressive results of which upon the lower river now threaten the existence of New Orleans. The Mississippi Commission is more open to criticism for permitting the demands of a few steamboat captains to prevent them from closing the Atchafalaya than on any other point. The maintenance of a single channel made the Mississippi more than 100 feet deep at and above New Orleans, sinking the river bottom far below gulf level; the Atchafalaya outlet has shoaled it very materially, and raised the flood height several feet. What then might be expected from an outlet through Lake Pontchartrain as suggested by "A Southern Engineer"? There can be no doubt that it would practically destroy the present lower river by silting it up, and raise the flood height ten feet or more, and in course of time extend the delta much farther than even "A Southern Engineer" would considerable desirable. An outlet to the East into Mississippi Sound would debouch the river into very shallow water upon the slightly-submerged bench of the old continent. It would be trying to make water run without fall and to follow a circuitous route where now, after rounding English Turn, it flows in a nearly straight line; and the ultimate greater length and crookedness of channel would multiply several times the head necessary to carry the water into the Gulf, making Louisiana one vast swamp and closing the Mississippi to commerce.

The writers quoted desire a delta. Can they name a single river discharging through a delta which is not a breeder of swamps and fevers, a menace to the inhabitants of its alluvial district, and a puzzle to engineers? The delta should be abolished altogether, and all the waters of the valley should be discharged through one

deep, narrow mouth. A stated quantity of water will be discharged through one large pipe with very much less head than through a number of small ones of equal length and equal total area.

That the laws of nature apply to the Mississippi the same as to other streams is proved by the fact that the slope through the delta is rather more than *seven times* the slope of the river between Head of Passes and Bayou Sara. The inference is plain that the improvement of the Mississippi should begin at the Gulf; and the first step should be the construction of parallel jetties confining the river to a width of not over 3000 feet. From deep water at say, the five-fathom curve, the artificial banks should be made continuous, without the possibility of breaking, up to Natchez, and along the Red, Black and other rivers discharging into the section of low slope. The Atchafalaya and every other outlet should be closed and kept closed. It is capable of demonstration that this measure would in time render levees unnecessary above Natchez, if supplemented by bank-protection and grading and straightening the river.

The proper location of the mouth of the Mississippi is at or adjacent to South Pass. The line of greatest fall of the submerged bench of the old continent is the line of least resistance to the discharge, and on this line the river has built itself from English Turn to Head of Passes. A line continuing this stretch across and at right-angles to the contour lines of the gulf-floor passes to the northeast of the mouth of South Pass, crossing Garden Island Bay. The fall from Cairo to the five-fathom curve is about six inches to the mile; from the five-fathom curve outward the fall is 90 to 100 feet and upward per mile. The river built to the edge of the old continent; man must step in and finish the work upon the lines laid down by nature.

The distance from Head of Passes to the proper deep-water mouth is about ten miles. The present slope through the delta is about seven times the slope from Head of Passes to Bayou Sara. To confine the river to one deep narrow mouth on the line of least resistance will abolish the delta, make the slope uniform from the mouth to a point in the vicinity of Natchez, and reduce the river heights throughout the alluvial region, the corrected height at Natchez being about the present height at Bayou Sara; and the right beginning being made, the good work will go on up the river until the entire river from Natchez to Cairo will be so far sunk below the surface of the country that levees will be unnecessary in

that section. It is a simple proposition that since the country slopes six inches per mile, and the river, in its lower reach, can discharge its maximum volume with a slope of 1½ inches per mile, therefore reckoning up-stream, the elevation of the land will gain relatively to high-water mark at the rate of 4½ inches per mile; and in 100 miles the banks will have gained 37½ feet in elevation, and in a given number of miles reckoned from the intersection of the plane of original slope of the country with gulf-level, the banks will have become high enough to safely retain the flood-wave.

The section of low slope of the Mississippi now begins in the vicinity of Bayou Sara, 269 miles by the river from the five-fathom curve at the proposed new mouth; and the head gained by the reduction of slope which will follow the abolishment of the delta by discharging the river through a single narrow mouth on the line of least resistance, will extend the section of low slope to the vicinity of Natchez, 100 miles further up-stream, and that without straightening the channel at all between Natchez and Carrollton. The flood height at Natchez under the improved conditions will not much exceed 46 feet; and since the country thereabouts averages 60 to 65 feet in elevation, the natural banks will be 15 to 20 feet above high-water, and levees will be unnecessary.

Above Natchez the slope of the river is necessarily greater, the average between Natchez and Cairo being 4.428 inches per mile at high-water, the actual difference between high-water marks being 258.3 feet. The air-line distance between the two places being 400 miles and the distance by the river 700 miles and the crooked and irregular channel necessitating slopes in some places of over seven inches, exceeding the slope of the land, it is obvious that the river must be straightened in order to keep it in its channel without the aid of levees. The worst bends occur between Natchez and Memphis, and all the straightening can be done between those two points, although I should advocate cutting off New Madrid bend. Fifty miles can be advantageously taken from the river's length, making the total length from Cairo 1020 miles.

The net result at Cairo would be to lower high-water mark from 321½ to about 285 feet above tide. To lower the river to this extent will free from inundation nearly 30,000 square miles of land and drain and bring under cultivation over 22,000,000 acres of land now swamp, an area greater than the entire farm acreage of New England. The money value to be gained is about the

value of the entire State of Ohio. The sanitary result will be beyond computation in money units.

Correlated with the work of channel-improvment in the lower Mississippi and coördinate in importance is the development of reservoir-capacity upon the tributaries, both by making permanent reservoirs at convenient sites, and developing the channel-reservoir system and navigation at the same time by building movable dams.

## II.—THE YELLOW RIVER AND THE PO.

*By H. St. L. Coppée.*

THE article in the June number of this magazine entitled "Impending Disaster on The Mississippi," written by "A Southern Engineer," brushes aside in nonchalant fashion all the accepted data and laws governing the action of the Mississippi river on which its improvements and regulations by normal contraction (revetment and dikes) are based. Having had some little experience as an engineer on the Mississippi, in the construction of its dikes, I feel impelled to take to task this anonymous writer. I have no desire to write a long article in answer to the broad assertions made, but will simply call attention to a few facts.

The approximate time of the greater annual rise and fall of the Mississippi river is well known. As on the Nile, at certain seasons high and low stages occur with considerable regularity, but with the advantage in this country that the people along the main leveed river are notified many days in advance of the coming changes by our efficient Signal Service, and can estimate approximately the duration and general effect of both flood and low-water conditions. The statement that the lower Mississippi, "from an almost sluggish stream at times becomes a very hell of surging waters in only a few brief hours," may be very fine rhetoric but it is not correct. The water rises sometimes two and three feet in twenty-four hours, but this is exceptional, and the velocity increases, but the visible change is perceptible only on close observation. In twenty-four hours a two-foot rise would hardly give an increase in mean velocity of three-tenths of a foot per second, the mean velocity being for mean stages between three and four feet per second and at flood but from five to six-and-a-half.

"A Southern Engineer" continues: "The writer has seen even a tributary river, the Tennessee at Chattanooga, rise fifty feet in a

short time; with this exhibition in memory it is easy to realize what a tremendous volume of water may be poured into the lower Mississippi, when a season of general rains has swollen all its tributaries to the point of overflow and danger." It happens, however, that during the recent floods, while the river from Cairo to the Gulf was full to within a foot or two of the top of the levees, excessive rainfall occurred all through the drainage area of the Missouri, upper Mississippi and Arkansas rivers, inundating for days a part of St. Louis, and numerous other cities and villages situated on these streams. What effect did this great combined rise and flood have on the Mississippi river at Helena, Arkansas, about a third of the way from Cairo to the Gulf, at the outlet of the great St. Francis Basin, where the river is confined to a small section between the hills on one side and levee on the other; or at Arkansas City, about 130 miles further down stream and just below the mouth of the Arkansas river? It did not cause the river to rise at either place one single half-foot. The fifty-foot rise noted above would have even less effect, being so remote from the main leveed river and occurring on a tributary of such comparative small discharge, and where the freshets are of such short duration.

With regard to the statement that dikes or levees built along the shore must and do result in raising the bed of the river, and the examples of the Po, Yellow river, etc., it is difficult to appreciate the purport of the article in question. It has been demonstrated by actual experiment that as the water rises in the Mississippi river the velocity increases until the top of the natural bank is reached; if a further rise takes place and the water is allowed to escape laterally over the country, the velocity in the channel is checked. We know also that the ability of the river to carry sediment is due to its velocity. If this velocity is reduced the sediment will be dropped and less carried in suspension to the Gulf; this increase in deposit raises the bed of the river and builds up the adjacent banks, very little sediment being carried far into the back country. Thus the general profile of cross section of the river will gradually rise and has risen *where not leveed.* Where levees confine the river at flooded stages to a normal width the reverse is the case. It is not claimed by the advocates of the levee and contraction system that there will be an appreciable or immediate lowering of the bed of the river by carrying out the levee feature of their plans. That it will take many years before a decided general effect of that kind will be reached is fully appreciated; but that the opposite effect or

the raising of the bed to any measurable amount in centuries to come will take place is not admitted, arguing from history and the experience on other rivers of a similar regimen. Take for example the very rivers noted by "A Southern Engineer"—the Po, the Rhine, and the great Yellow river of China. A few extracts from the testimony of General Comstock, given before the Committee on Commerce of the United States Senate, March 13 and 14, 1890, will be sufficient to show the effect, or rather non-effect, of levees on the bed of these rivers. General Comstock, President of the Mississippi River Commission and an officer of the Engineer Corps of the Army, is certainly the most profoundly learned engineer in America as regards alluvial rivers and the Mississippi in particular. He testifies:

"The statement is often made that leveed rivers raise their beds higher and higher as levees are raised, and hence that levees will give no permanent relief against overflow. These statements are usually made * * * probably without any knowledge of the facts of experience. * * * The river Po has long been leveed, and it is often stated that its bed has risen largely in consequence of levees. The following data will show how unfounded is the statement that the bed has risen by amounts that are of much importance: At the revival of civilization the levees on the Po were complete and continuous from Cremona to the mouth of the Oglio, 94 kilometers, or 58.4 miles. About A. D. 1300, they were carried farther down the river and in the succeeding centuries to near its mouth. In the present century levees have been systematized as to height. Four hundred kilometers, or 248½ miles, were below the flood of 1872. At the end of 1877 it was expected to reduce this to about 30 kilometers, or 18 miles. [Cenni Monografici sull' idraulica fluviale in Italia. Roma, 1878.] Zendrini in 1720 observed an extreme low water at Ponte Lagoscuro, only .36 foot less than that of 1817; and at the dam of Governolo, near the mouth of the Mincio, the river was 1.3 feet lower than a stage of water of 1609, declared by Bardazzoli to be marvelous [Lombardini, Notizii].

"The 'Cenni Monografici' gives the following:

PONTELAGOSCURO.

| Years. | Mean Lowest Water. | Mean Highest Water. | Maximum High Water. | Minimum Low Water. |
|---|---|---|---|---|
| | M. Ft. | M. Ft. | M. Ft. | M. Ft. |
| 1807–1825 | 3.28=10.4 | 7.42=24.3 | 8.62=28.3 | 0.38=1.3 |
| 1826–1850 | 3.26=10.3 | 7.38=24.2 | 8.96=29.4 | 0.72=2.3 |
| 1851–1875 | 3.19=10.1 | 7.39=24.2 | 9.32=30.5 | 0.62=2.0 |

"The above gage-readings, which have been only kept since 1807, show that there has been no important rise of the bed of the river (since that could not rise without raising the low-water surface) at Pontelagoscuro in the sixty-eight years covered, and in connection with Zendrini's observations show that there has been no probable rise of any importance since 1720, although the raising of levees has been going on during this period. Lombardini [Dei Congiamenti del Po, 1852, p. 17]

examines this question for points above Pontelagoscuro, which itself is 92 kilometers (57 miles) from the mouth of the Po. He concludes that at Ostiglia, which is 183 kilometers (114 miles) above the mouth, the bed appears to have risen a few decimeters (decimeter=3.9 inches) in a century, while at Governolo 15 kilometers (9⅓ miles) above, it appears to have been stationary for four centuries. * * *

"The Rhine is also a river which below Dusseldorf has long been leveed, and if levees raise the bed of a river here they should have produced their full effects, as they are rarely broken. Hagan [Wasserstande in den Preussischen Stromen, p. 12] carefully examined the gage-readings at Cologne, from 1846 to 1879, and at Dusseldorf, from 1800 to 1879, to detect changes in high- and low-water heights. Treating the gage-reading by the method of least squares, he found the most probable annual change in the water heights. At Dusseldorf he found that, with great probability, there was an annual sinking of the maximum high-water in each year amounting to 0.3 inch ; that the mean stage did not change, and that the annual lowest waters showed, with some probability, an annual rise of one-twelfth of an inch. For Cologne he found that, with great probability, the high waters had sunk, and the lowest waters had risen by about the same amounts as at Dusseldorf. A rise of one-twelfth of an inch a year, or eight inches in a hundred years, is so small as not to be an important matter in a system of levees. * * *

"It has often been asserted that the bed of the Hoang Ho, or Yellow river of China, has risen above the surrounding country where it is leveed. The error, originally due to Abbe Huc, has been repeated by English writers on China. The following extract from a letter to me by General J. H. Wilson, a very competent authority, gives reliable information on the subject :

"'WILMINGTON, DEL., May 6, 1890.

"'* * * In reply I hasten to say that I crossed the Yellow river on the 7th of January, 1866, near the city of Kai-fong-fu, in the province of Honan, and visited the site of the great break of 1853, about thirty miles below Kai-fong-fu ; also traversed its embankments or levees on both banks of the river, visiting and measuring them at various points between Kai-fong-fu and Chinau-fu, in the province of Shan-Toong, taking observations, notes and measurements, and having specially in view the repair and maintenance of the embankments, their present condition, and the effects produced by them. I had no instruments, however, except a hand-level, sextant and tape-line, and could take no accurate levels across embankments, bed of the stream, fore-shores, and adjacent plains, but the conclusion I came to in regard to the influence of the levees upon the bed of the river was that they had nowhere filled it to a higher level than the adjacent country. I had heard Father Huc's narrative on that point, and I visited the place at which the river had left its old channel in 1853, leading to the sea south of the peninsula of Shan-Toong, and made itself an absolutely new one to the Gulf of Pe Chi Li, north of that peninsula. Between this place—known on the maps of Asia (Kirke Johnson's is the best) as Lung-mum-Ku—and Kai-fong-fu, the embankment was very large but it was near the latter place that the great break occurred two years ago. This was closed after incredible efforts and great expense and this river forced to resume its old channel, where it is now emptying itself, according to my advices of a few months ago, and where it will most probably continue to empty itself till it can find a shorter line, and

steeper declivity to tide-level. By referring to my little book on China (Appleton & Co.) you will get other details.

"'In conclusion, I do not hesitate to say that I cannot but believe that Abbe Huc was entirely mistaken in regard to the silting up of the channel, and that an exhaustive survey would prove beyond a doubt that no such silting as to raise any part of the bed above the adjacent country had ever taken place. Yours very truly,

"'JAMES H. WILSON.'"

It is hardly necessary to go further; the suggestions for the improvement of the Mississippi based on such principles as those offered by "A Southern Engineer" are of little value. The outlet of a river known to be, by actual measurement in this country and abroad, the cause of the raising of the flood level; cut-offs invariably destroy valuable property, upset the general regimen of the river at points above and below, as well as in their immediate vicinity, in no way bettering either navigation or the riparian owner.

Dike-building may be "rudimentary engineering," but it has played an important part in the history of the world. It dates back to the ancient civilizations of India and Egypt. Great cities have grown up and flourished behind the protecting slopes of dikes. The Dutch raised a kingdom from the sea, and the northern Rhine, by their construction. To-day on the Mississippi river in a similar manner is being developed one of the richest agricultural countries in the world. The very railroads referred to by "A Southern Engineer," that are being built "as fast as their construction can be promoted by enterprise and profit," would not exist but for the protection promised by the levee system.

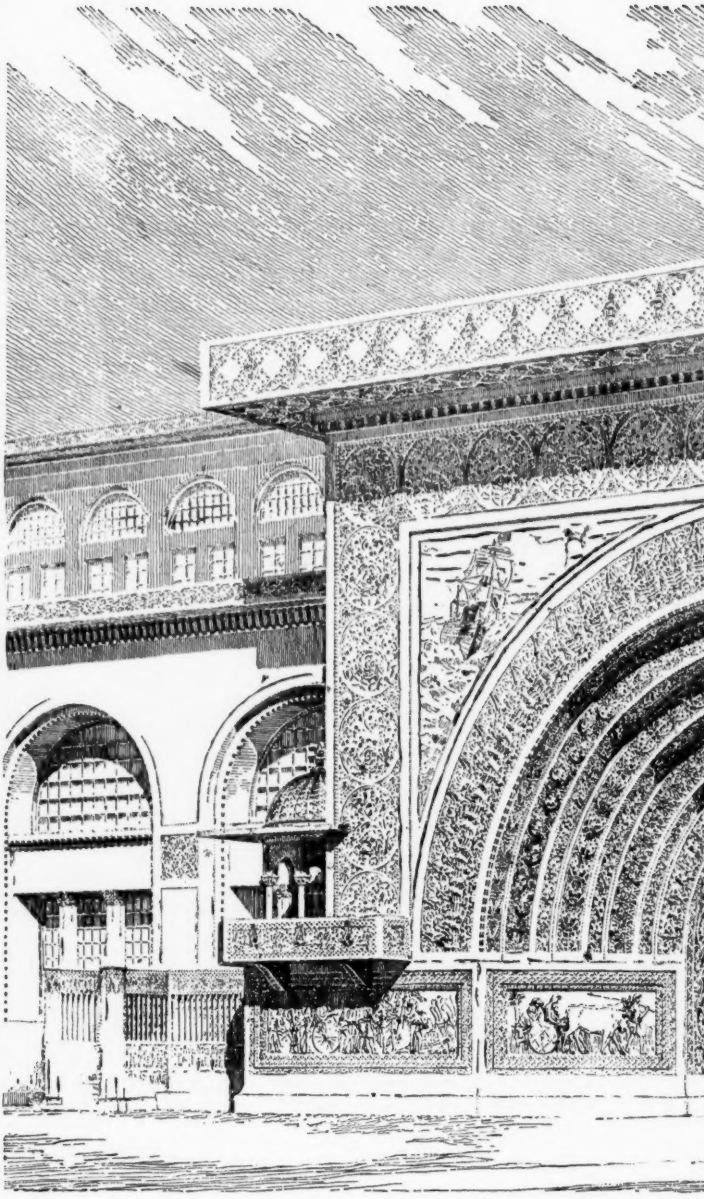
The increase in levee efficiency and protection against overflow, and the benefit to navigation promoted already by the partial carrying out of the plans of the Mississippi River Commission and assisting riparian States, can be demonstrated in a very few words. The low-water crossings that were as shoal as 4 and 5 feet previous to 1880 have been increased in depth at lowest stages to 7 feet and over. At Plumpoint Reach, where special work has been carried on, the depth since the work begun has been doubled, and the navigable capacity of this portion of the stream has been multiplied by eight. The following is an extract from a report of a committee of engineers of which I was a member, appointed to report to the Interstate Mississippi Improvement and Levee Convention held at Vicksburg, Mississippi, May 30, 1890:

"In 1882 the total number of crevasses in the levees was 284, aggregating 56.09 miles in width; in 1883 the number of crevasses was 224, with an aggregate

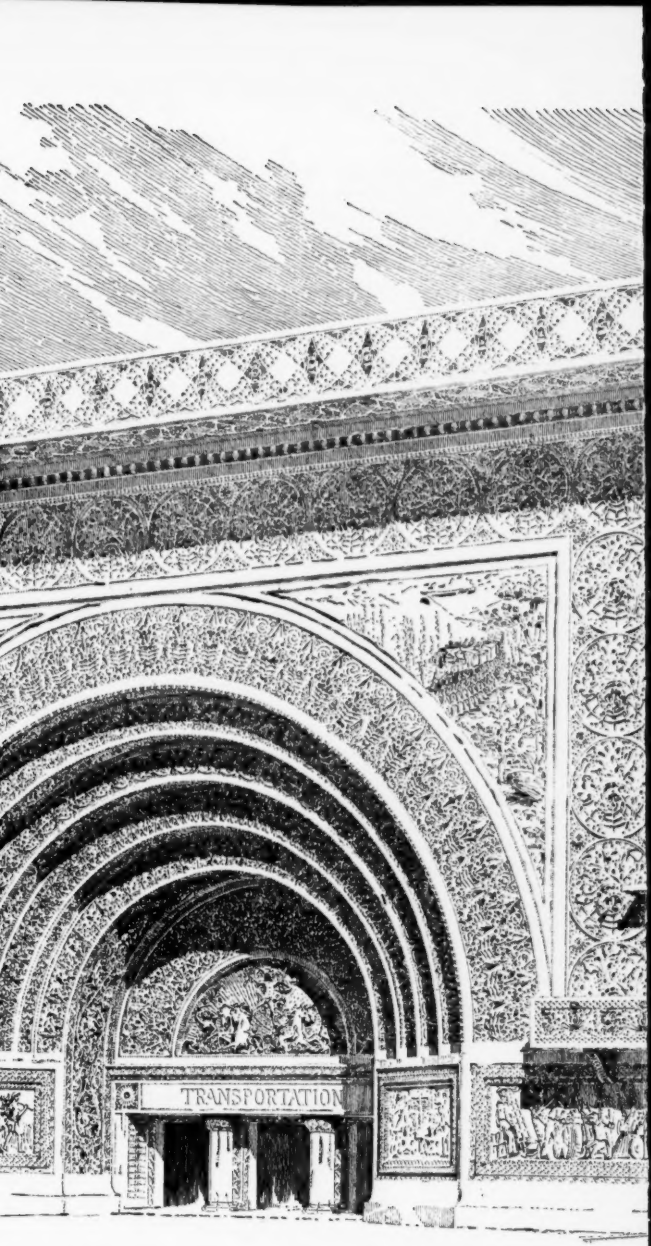
width of 34.1 miles; in 1884 the crevasses numbered 204, aggregating 10.64 miles in width. The result of the crevasses enumerated during these three years was a general overflow of the Mississippi Delta. In the present flood, the dangers of which are nearly passed, the crevasses which have occurred number 23, aggregating about 4¼ miles in width, in a total length of 1100 miles of levees, or less than half of 1 per cent. of the total line of levees. The general result has been a large measure of protection afforded by the levees this year, notwithstanding the extraordinary character of the flood, which has never been enjoyed during previous high waters of considerable magnitude.

"For example in the Yazoo Basin between 80 and 85 per cent. of its area is protected from overflow, there being only one crevasse of 280 feet in width, affecting a very small area, in 180 miles of levee extending from the upper extremity southward. There were other crevasses on this front below this locality. On the Tensas front are two reaches of continuous levee, being respectively 81 and 125 miles in length; the right bank below Red river has 180 miles of continuous unbroken levee, and the left bank has 200 miles with only one break. Of the territory dependent upon the last-named levees, 75 per cent. has been protected."

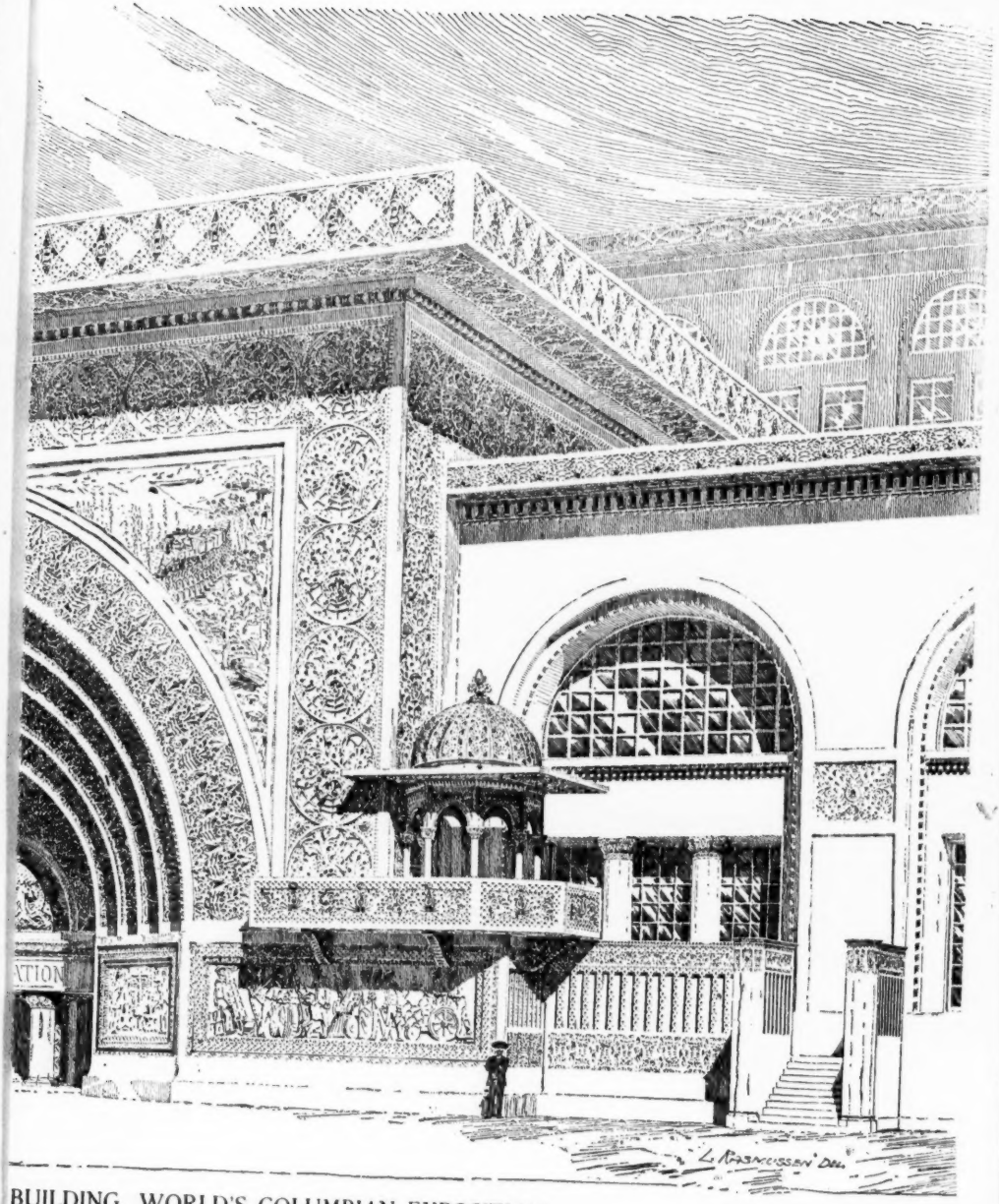
In 1891 the flood that was practically as great as that of 1890 below the Arkansas river, caused but five crevasses, aggregating about one mile of lateral opening, out of the total length of about 1300 miles of levee below Cape Girardeau, Missouri. The present flood but adds more convincing evidence of the benefit derived from a levee system constantly increasing in perfection. But for a few slight breaks near the mouth of the Arkansas river the entire river has been practically carried between levees from Memphis to near New Orleans. The State of Mississippi has been protected from inundation, not a single break having occurred on her front. With liberal appropriations it is only a matter of a very few years when the control of the Mississippi floods will be an accomplished fact beyond dispute or argument.



GOLDEN DOORWAY, T




VAY, TRANSPORTATION BUILDING, WORLD'S COLUMBI



BUILDING, WORLD'S COLUMBIAN EXPOSITION.

# ORNAMENT IN ARCHITECTURE.

*By Louis H. Sullivan.*

I TAKE it as self-evident that a building, quite devoid of ornament, may convey a noble and dignified sentiment by virtue of mass and proportion. It is not evident to me that ornament can intrinsically heighten these elemental qualities. Why, then, should we use ornament? Is not a noble and simple dignity sufficient? Why should we ask more?

If I answer the question in entire candor, I should say that it would be greatly for our esthetic good if we should refrain entirely from the use of ornament for a period of years, in order that our thought might concentrate acutely upon the production of buildings well formed and comely in the nude. We should thus perforce eschew many undesirable things, and learn by contrast how effective it is to think in a natural, vigorous and wholesome way. This step taken, we might safely inquire to what extent a decorative application of ornament would enhance the beauty of our structures—what new charm it would give them.

If we have then become well grounded in pure and simple forms we will revere them; we will refrain instinctively from vandalism; we will be loth to do aught that may make these forms less pure, less noble. We shall have learned moreover that ornament is mentally, a luxury, not a necessary; and that we should so use and understand it. We shall have learned by contrast wherein this luxury may become emotionally a necessary, for we shall have discerned the limitations as well as the great value of unadorned masses. We have in us romanticism, and feel a craving to express it. We feel intuitively that our strong, athletic and simple forms will carry with natural ease the raiment of which we dream, and that our buildings thus clad in a garment of poetic imagery, half hid as it were in choice products of loom and mine, will appeal with redoubled power, like a sonorous melody overlaid with harmonious voices.

I conceive that a true artist will reason substantially in this way; and that, at the culmination of his powers, he may realize this ideal.

I believe that architectural ornament brought forth in this spirit is desirable, because beautiful and inspiring; that ornament brought forth in any other spirit is lacking in the higher possibilities.

VIEW OF BALCONY, SCHILLER THEATER, CHICAGO.

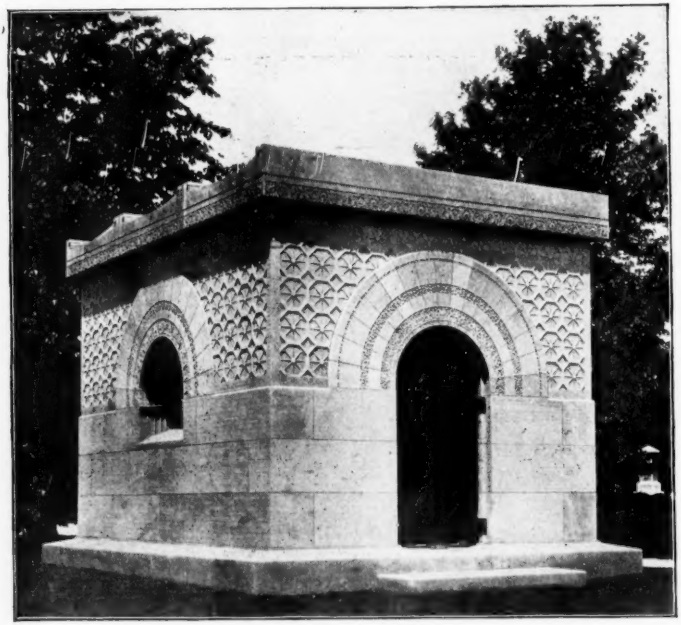
That is to say, a building which is truly a work of art (and I consider none other), is in its very nature, essence and physical being an emotional expression. This being so, and I feel deeply that it is so, it must have, almost literally, a life. It follows from this living principle that an ornamented structure should be characterized by this quality, namely, that the same emotional impulse shall flow throughout harmoniously into its varied forms of expression—of which, while the mass-composition is the more profound, the decorative ornamentation is the more intense. Yet must both spring from the same source of feeling.

I am aware that a decorated building, designed upon this princi-

DISTANT VIEW OF TOWER, SCHILLER THEATER.

ple, will require in its creator a high and sustained emotional tension, an organic singleness of idea and purpose maintained to the last. The completed work will tell of this; and if it be designed with sufficient depth of feeling and simplicity of mind, the more intense the heat in which it was conceived, the more serene and noble will it remain forever as a monument of man's eloquence. It is this quality that characterizes the great monuments of the past. It is this certainly that opens a vista towards the future.

To my thinking, however, the mass-composition and the deco-



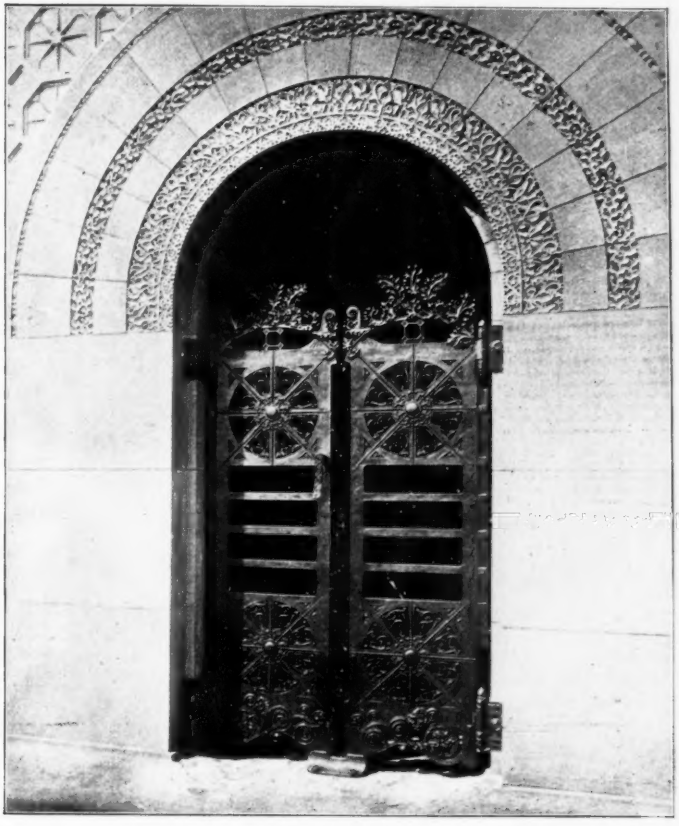
GETTY TOMB, GRACELAND CEMETERY, CHICAGO.

rative system of a structure such as I have hinted at should be separable from each other only in theory and for purposes of analytical study. I believe, as I have said, that an excellent and beautiful building may be designed that shall bear no ornament whatever ; but I believe just as firmly that a decorated structure, harmoniously conceived, well considered, cannot be stripped of its system of ornament without destroying its individuality.

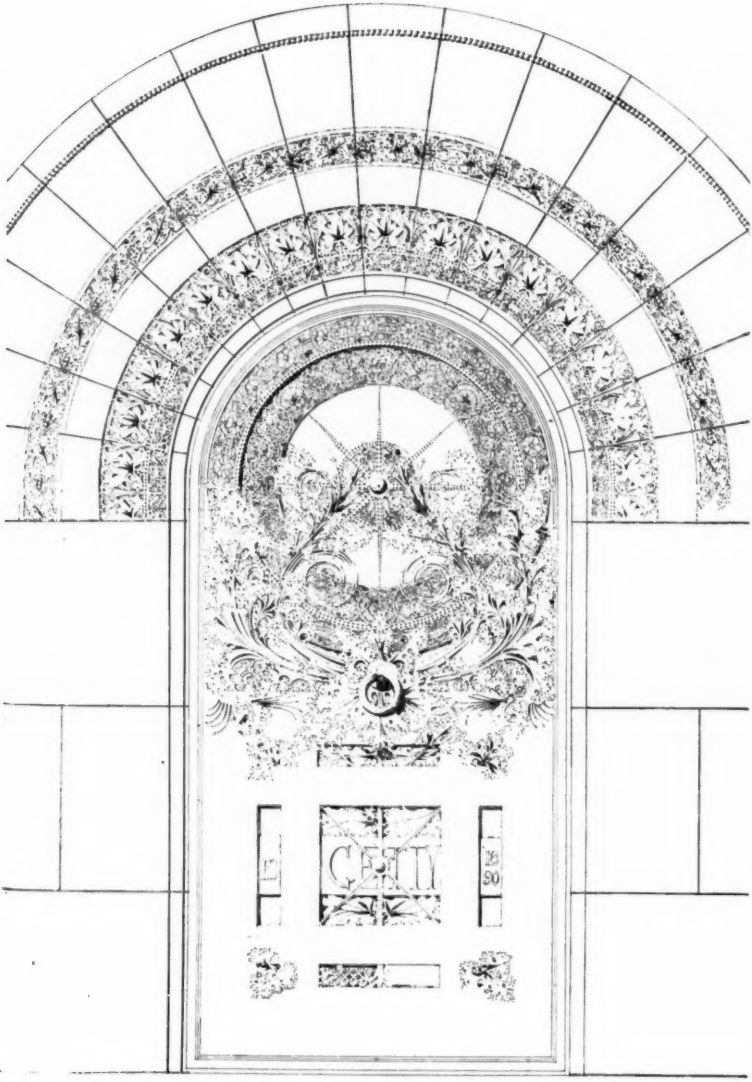
It has been hitherto somewhat the fashion to speak of ornament, with perhaps too much levity of thought, as a thing to be put on or omitted, as the case might be. I hold to the contrary—that the presence or absence of ornament should, certainly in serious work, be determined at the very beginnings of the design. This is perhaps strenuous insistence, yet I justify and urge it on the ground that creative architecture is an art so fine that its power is manifest in rhythms of great subtlety, as much so indeed as those of musical art, its nearest relative.

If, therefore, our artistic rhythms—a result—are to be significant, our prior meditations—the cause—must be so. It matters then greatly what is the prior inclination of the mind, as much so indeed as it matters what is the inclination of a cannon when the shot is fired.

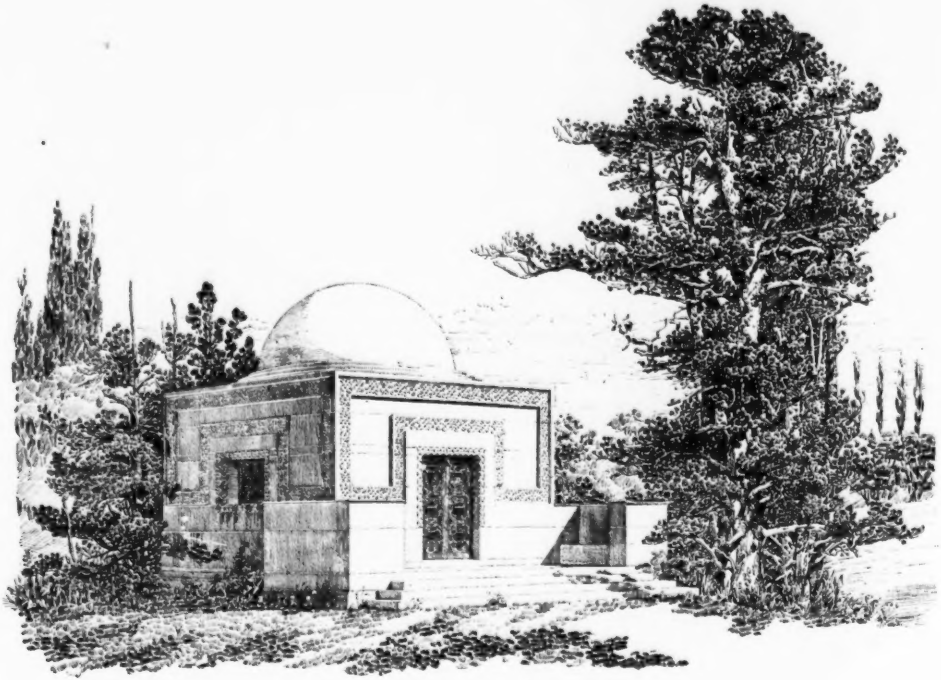
If we assume that our contemplated building need not be a work of living art, or at least a striving for it, that our civilization does not yet demand such, my plea is useless. I can proceed only on the supposition that our culture has progressed to the stage



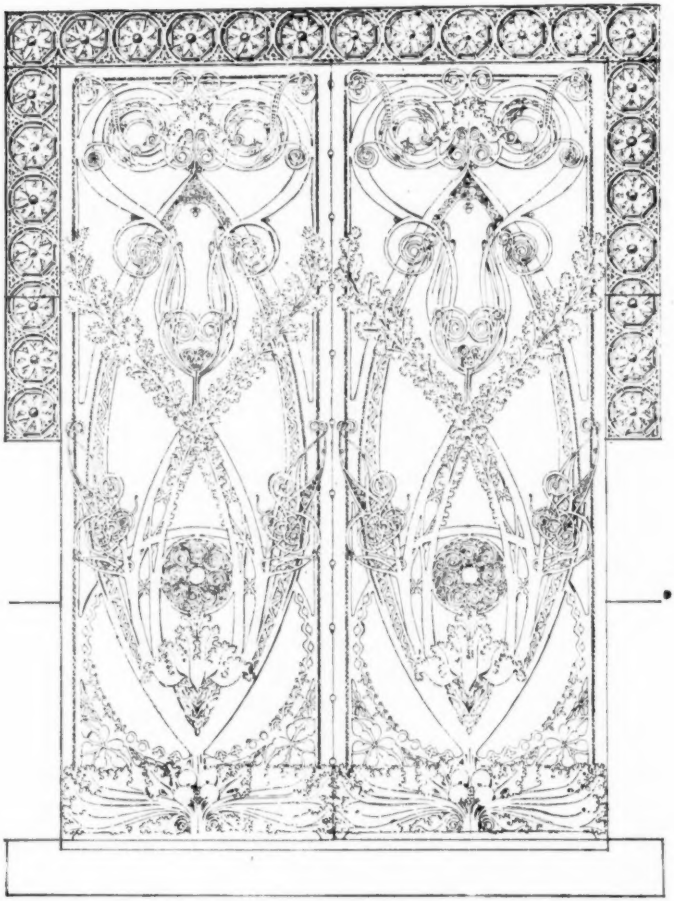
BRONZE GATES, GETTY TOMB.




STONE ARCHWAY AND BRONZE DOOR, GETTY TOMB.



THE WAINWRIGHT MEMORIAL, ST. LOUIS, MO.



BRONZE GATES, WAINWRIGHT MEMORIAL.

wherein an imitative or reminiscential art does not wholly satisfy, and that there exists an actual desire for spontaneous expression. I assume, too, that we are to begin, not by shutting our eyes and ears to the unspeakable past, but rather by opening our hearts, in enlightened sympathy and filial regard, to the voice of our times.

Nor do I consider this the place or the time to inquire if after

all there is really such a thing as creative art—whether a final analysis does not reveal the great artist, not as creator, but rather as interpreter and prophet. When the time does come that the luxury of this inquiry becomes a momentous necessary, our architecture shall have neared its final development. It will suffice then to say that I conceive a work of fine art to be really this: a made thing, more or less attractive, regarding which the casual observer may see a part, but no observer all, that is in it.

It must be manifest that an ornamental design will be more beautiful if it seems a part of the surface or substance that receives it, than if it looks "stuck on," so to speak. A little observation will lead one to see that in the former case there exists a peculiar sympathy between the ornament and the structure, which is absent in the latter. Both structure and ornament obviously benefit by this sympathy—each enhancing the value of the other. And this, I take it, is the preparatory basis of what may be called an organic system of ornamentation.

The ornament, as a matter of fact, is applied in the sense of being cut in or cut on, or otherwise done; yet it should appear, when completed, as though by the outworking of some beneficent agency it had come forth from the very substance of the material and was there by the same right that a flower appears amid the leaves of its parent plant.

Here by this method we make a species of contact, and the spirit that animates the mass is free to flow into the ornament—they are no longer two things but one thing.

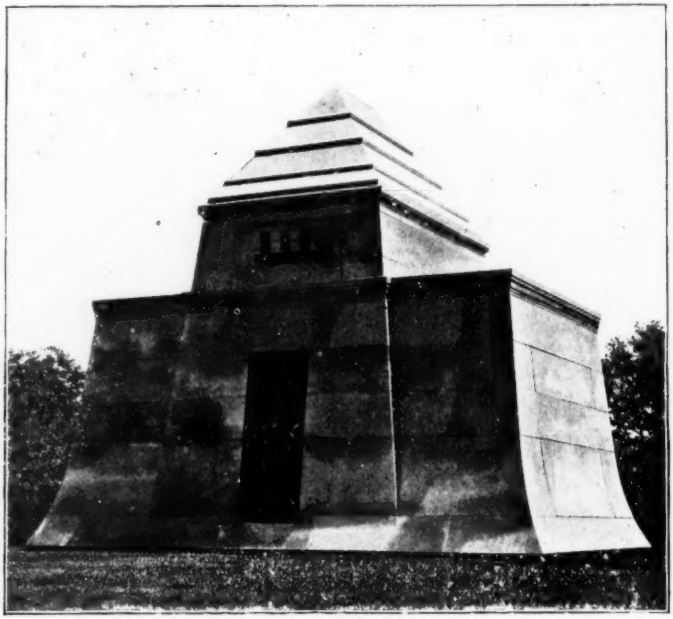
If now we bring ourselves to close and reflective observation, how evident it becomes that if we wish to insure an actual, a poetic unity, the ornament should appear, not as something *receiving* the spirit of the structure, but as a thing *expressing* that spirit by virtue of differential growth.

It follows then by the logic of growth, that a certain kind of ornament should appear on a certain kind of structure, just as a certain kind of leaf must appear on a certain kind of tree. An elm leaf would not "look well" on a pine tree—a pine needle seems more "in keeping." So, an ornament or scheme of organic decoration befitting a structure composed on broad and massive lines would not be in sympathy with a delicate and dainty one. Nor should the ornamental systems of buildings of any various sorts be interchangeable as between these buildings. For buildings should possess an individuality as marked as that which exists among

men, making them distinctly separable from each other, however strong the racial or family resemblance may be.

Every one knows and feels how strongly individual is each man's voice, but few pause to consider that a voice, though of another kind, speaks from every existing building. What is the character of these voices? Are they harsh or smooth, noble or ignoble? Is the speech they utter prose or poetry?

Mere difference in outward form does not constitute individu-



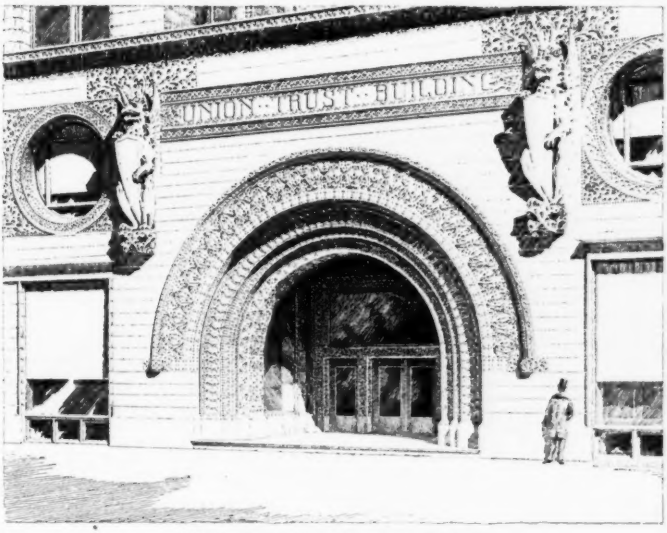
RYERSON TOMB, GRACELAND CEMETERY, CHICAGO.

ality. For this a harmonious inner character is necessary; and as we speak of human nature, we may by analogy apply a similar phrase to buildings.

A little study will enable one soon to discern and appreciate the more obvious individualities of buildings; further study, and comparison of impressions, will bring to view forms and qualities that were at first hidden; a deeper analysis will yield a host of new sensations, developed by the discovery of qualities hitherto unsus-

pected—we have found evidences of the gift of expression, and have felt the significance of it; the mental and emotional gratification caused by these discoveries leads on to deeper and deeper searching, until, in great works, we fully learn that what was obvious was least, and what was hidden, nearly all.

Few works can stand the test of close, business-like analysis—they are soon emptied. But no analysis, however sympathetic, persistent or profound, can exhaust a truly great work of art. For the qualities that make it thus great are not mental only, but psychic, and therefore signify the highest expression and embodiment of individuality.




ENTRANCE UNION TRUST BUILDING, ST LOUIS.

Now, if this spiritual and emotional quality is a noble attribute when it resides in the mass of a building, it must, when applied to a virile and synthetic scheme of ornamentation, raise this at once from the level of triviality to the heights of dramatic expression.

The possibilities of ornamentation, so considered, are marvelous; and before us open, as a vista, conceptions so rich, so varied, so poetic, so inexhaustible, that the mind pauses in its flight and life indeed seems but a span.

Reflect now the light of this conception full and free upon joint

considerations of mass-composition, and how serious, how eloquent, how inspiring is the imagery, how noble the dramatic force that shall make sublime our future architecture.

America is the only land in the whole earth wherein a dream like this may be realized; for here alone tradition is without shackles, and the soul of man free to grow, to mature, to seek its own.

But for this we must turn again to Nature, and, hearkening to her melodious voice, learn, as children learn, the accent of its rhythmic cadences. We must view the sunrise with ambition, the twilight wistfully; then, when our eyes have learned to see, we shall know how great is the simplicity of nature, that it brings forth in serenity such endless variation. We shall learn from this to consider man and his ways, to the end that we behold the unfolding of the soul in all its beauty, and know that the fragrance of a living art shall float again in the garden of our world.

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NOTE—The illustrations accompanying this article are selected from the work of Messrs. Adler & Sullivan, architects.—EDITOR.

# DOES CAPITAL NEED HIGH-PRICED LABOR?

*By W. E. Partridge, M. Am. Soc. M. E.*

THE most serious labor troubles are largely if not entirely due to a wrong theory with regard to wages which is so deeply rooted in the minds of both laborer and capitalist that it has come to be accepted as an axiom. It may be stated thus: Cheap labor makes cheap goods—the cheaper the labor the cheaper the product. Believing this the manufacturer, when he finds that the cost of a product must be lowered, first considers the question of a reduction of wages. This apparently is the simplest of all mathematical problems. A certain percentage deducted from the pay-roll means a like amount added to the profit account or subtracted from the cost. To take so much out of the pocket of the workman and put it into the bank-account of the employer is a question easily solved without the use of pencil and paper. In the light of such reasoning war is a natural result, each party feeling its position to be perfectly justifiable. The workman feels that he has the right, if he can, by means of a strike or otherwise, to send wages up out of all proportion to the cost of the product. The capitalist, on the other hand, too often takes revenge in kind and cuts wages to the starvation point.

From time out of mind it has been the habit to tell the apprentice, just beginning the use of tools, that that which seems to be the easiest way is the wrong way. The same is true in every department of human endeavor. It is safe to ask, therefore, whether this easy way of disposing of the relations of capital and labor is not the wrong way. The fact that cutting down wages puts a profit upon goods which otherwise would be sold at a loss is one of those half truths which are more deceptive than absolute falsehoods. Time is an element in all lines of business, and the result which time will produce is always to be considered. For example, by keeping up the appearance of goods while reducing the quality it may be possible to increase the profit for a while, but in the end a business carried on in this way becomes unprofitable. So it is only a question of time for the cutting of wages to produce results the opposite of what the manufacturer hopes for. Wages in America for a long series of years have been high as compared with wages on the continent of Europe, in spite of which we have steadily held

our own, keeping our foreign markets and often gaining new ones in competition with the cheap labor of other countries. Here the conditions of labor have forced us to adopt to some extent the true theory of work and wages, but the influx of foreign workmen and the growth of trade-unionism has helped to root the wrong ideas. The trade-union holds the same theory as the manufacturer, that cheap labor makes cheap products. It recognizes, however, the hopelessness of its task of fighting for higher wages in the face of this belief.

The mistake of the trade-union, as well as of the manufacturer, lies in its fundamental idea of the relation of wages to product. It is capable of demonstration that high-priced labor makes cheap goods. The prosperity of our country from the earliest times is a proof of this fact. The slowly waning prosperity of many industries in Europe is another proof. Before entering upon our demonstration the question must be answered, "What is high-priced labor?" It is labor which is capable of earning a large amount of money. Because a man is paid a high price it does not follow that he earns it. A factory-girl working on a sewing-machine and turning out four pieces of work per hour is a high-priced laborer as compared with the girl who can turn out only one piece per hour. And the former is worth more than four times as much as the latter. It is this sense of high rate of earning that the labor and capital question must be considered. The manufacturer, then, who considers the ultimate success of his undertaking and its long-continued prosperity must study how he may increase the individual earnings of his operatives. He must seek for the highest-priced labor in order that he may have the greatest returns for his expenditure, just as he seeks for the most efficient machines, regardless of first cost. The problem is to adopt a system which shall utilize skill and intelligence.

That high-priced labor makes cheap goods may seem a paradox to those who have considered only the other side. But in England labor has been high as compared with that on the Continent. Yet England has held European markets in the face of this difference. From England cottons are sent to India and China in spite of the cheap labor of the latter countries. The view usually taken of this is that the use of machinery enables the English to manufacture so cheaply that they can compete with the almost "pauper" labor of China and India. This is a mistake; the cheap labor must be drilled and acquire a large increase of earning power

before it can run the machines of a cotton-factory. It must become skilled to such an extent that it no longer deserves to be termed "cheap." Machinery in this case requires that the cheap labor shall be increased in value in order to be useful.

The higher value of American labor as compared with that abroad and its consequent higher price is well shown by an incident in the sheet-metal stamping trade. A manufacturer in advertising his stamping and drawing presses abroad based his statements in regard to capacity upon the speed of 120 strokes per minute, habitually used in America. The foreign purchasers complained that they could not make half so many articles in a minute as he had promised. Visiting the shops in person he found no difficulty in feeding the blanks to the presses at the guaranteed rate of speed. But he found that the cheaper workmen employed could not keep up to such a rate. After that the guarantees advertised abroad were only half as large as the capacity of the machines in actual work at home. Thus the higher-priced laborer shows a decided advantage over the cheap workman. Doubling the output of a machine by merely changing the quality of the workman has advantages not often thought of. The use of machinery gives the greatest returns in those countries where the general intelligence is greatest and skill is most common, and where, in consequence, labor is the most highly paid. In countries where labor is cheapest machinery cannot be run with profit by the natives. A contractor in India is on record in a statement showing that the wheelbarrow is too complex and too large a tool to be used profitably on embankment work in some parts of that country. Labor which is too cheap to use a wheelbarrow is too poor to be of much value to capital.

What skilled, high-priced labor can do was well illustrated by an incident told by an American engineer who had been employed near the oil-wells of Batoum. Walking out one day he saw at a distance a hundred or more camels receiving peculiar-looking loads all alike. Approaching he found a caravan about to start for Persia, each camel bearing a box containing two sewing-machines of American make. Skilled labor of the most expensive kind has made it possible to manufacture a sewing-machine which is so effective and so cheap that it may be shipped half-way around the globe, and transported a thousand miles upon camels, to a land of low wages. Could skilled labor be obtained, capital would soon erect in Asia the necessary machinery to manufacture on the spot

and save the excessive cost of transportation. It is not alone highly specialized articles, like the sewing-machine, that are exported from lands of high wages to those of cheap labor. Goods of the most simple character are also exported. The manufactured articles imported from semi-civilized countries are those which have employed labor of the greatest skill or taste. As a rule it is the product of the greatest skill and most valuable labor that goes abroad.

An entirely different illustration may be drawn from the experience of a manufacturing firm in an Eastern State. The industry was established more than fifty years ago, being new in its line, and grew until it assumed large proportions. The distance from consumers was large, the cost of transportation was considerable and the price of labor high. These things led to the transfer of the factory to a point near Boston. The same reasons that had led to the first removal soon induced them to take a factory in New York, where the cheaper labor obtainable was a strong attraction. When time enough had passed to make it possible to compare the work in the three different places it was found that both the changes had been for the worse. Fine materials were so wasted or destroyed by the cheaper hands that there was a loss instead of a saving. So in spite of high wages, long transportation, high freights and long winters, it was found best to move the factory back to the little village in Maine where the enterprise had its beginning. There careful men and women were to be had whose economical use of the materials more than offset the shorter transportation and lower wages found elsewhere.

Cheap workmen may be sought in other ways to the disadvantage of the manufacturer. In western New York a few years ago, in a large shoe shop, at the regular price for piece-work, exceedingly good wages were made by the smarter girls, some of whom were paid $25 and even $30 each per week. The best class of girls were attracted to the place by the knowledge that such amounts were within the reach of those who could acquire the necessary skill and speed. The rank and file of the girls employed averaged at the time about $8 per week. Cut after cut was then made in the prices, because the employers thought that no girl ought to earn more than $10 per week. The result was hardly what was expected. The large class of capable women whom they had hoped to cut down to $10 left. The rank and file, far below them but still earning good wages, also left for more profitable work, while only the

poorer class remained, who were able to make but $5 or $6 per week. Probably the owners never understood fully what happened. It was this—the quality of the work suffered, the productiveness of the plant was cut down in nearly the same ratio as they hoped to reduce wages, and their most expert and valuable laborers were forced to leave them. On the other hand, one of the leading hardware manufacturers in New England stated recently that within fifteen years in several departments of his establishment he had put systems in operation which reduced "the labor cost on certain products without encroaching upon the earnings of the men employed."

The workman who earns high wages is especially valuable to his employer because from a given plant a much larger product can be obtained than is possible with the other class. It seems to be a wholesale transaction between labor and capital, with an advantage which is mutual. Even in the matter of excavating for sewers, cellars and the like, it pays to employ at high wages the best men. In New York city it is a common remark among contractors that they would rather have good men, costing from $1.50 per day upwards, than Italians at 75 cents. The number of men who can work in a given excavation being limited, those who can do the most work in a given time are the cheapest. But it is a matter of common knowledge that the Italian at 75 cents usually does but 50 cents worth of work. This entails a double loss. The work costs more and a longer time is required; the job is delayed and more capital becomes necessary for any given undertaking. This illustrates the principle completely. The cheap hand calls for more capital, a larger plant, a greater length of time, and is not able to give as much for a dollar as the other. This increase of the producing power of the plant is very important and an increase in the earning power of the men is usually found to be equivalent to an increase in the capacity of the establishment.

Besides producing more economically, and thus making money for the capitalist, there is another way in which the workman who earns large wages is valuable. Such men become property-holders; they are respected, conservative, self-respecting, intelligent, temperate citizens; their children grow up educated and "well-to-do" instead of swelling the pauper or criminal classes. Such citizens have a large purchasing power. Their prosperity is of the most stable character. Men of this class are not prone to have labor troubles. They have too much at stake to enter into rash, ill-ad-

vised contests. Manufacturing can be prosperous only through long periods in communities where the average income of the thrifty masses is large and their wants and their purchasing power on a corresponding scale—where wealth is widely distributed and incomes are ample, and steady consumption is enormous. Capital flourishes correspondingly.

While high-priced labor is desirable it must not be understood that the manufacturer should at once raise wages or increase the price of piece-work. Such a course would be disastrous. Advancing prices is not advancing the earning power. It is the latter which ought to be increased. The artificial advancement of wages without a corresponding increase in the ability to earn leads ultimately to a permanent decline in wages. This is a rule which appears to have no exceptions whatever in this country, having been proved by almost every industry from ship-building to mining. The incidental results arising from the artificial advancing of wages are of the worst character and are to be feared by both capitalist and workman.

A strange state of affairs now exists in England which has been interpreted in a variety of ways. As the price of labor in the great iron-making centers has fallen England has begun to feel Belgian and German competition. Structural-iron contracts have been sent to Belgium, and German cutlery has come into Sheffield in a way that has been a cause of great complaint among English cutlers and iron-masters. This has sometimes been looked upon as a case of cheap labor against that which is better paid. Others have said that this was part of that irrepressible conflict between machinery and man in which man, the laborer, was to be ground to powder unless machinery was first abolished. In the case of the English and Belgian iron trade it is a mere contest of machinery. In such a contest the latest comers, and those having the most capital, are always winners. Belgium and Germany had only to construct superior plants and they had control of the market. With natural facilities nearly similar it was merely necessary to employ a little more capital, build a little better machinery and they could command the situation.

To an attack of this kind there is but one method of reply—reduce wages and improve the machinery. Unfortunately for the English the Belgians could reduce wages more easily, and the improved machinery and processes of one country could be duplicated by the other within a year or two. Had the English iron-masters

turned their attention to the improvement of their labor as well as their machines, had they made one English cutler as good as three Belgians or Germans, the foreign competition would have been extinguished.

Ship-owners of the last generation learned a lesson which should not be lost upon the manufacturers of to-day. The American or English sailor was worth two of any other nationality. This was especially true of our American ships. Though they paid high wages it cost less to handle them than those of any other nation. Old sea-captains will speak with pride of voyages they made with fifteen men before the mast while French or Italian vessels of the same class would be manned by thirty men or more.

High-class labor gives a community a monopoly of a certain kind. Such labor cannot be exported. It cannot be duplicated by capitalists in another country. It is difficult even to take it from place to place in the same country. Providence, Hartford and Worcester hold a monopoly of a kind of skilled labor. A few of these men might be persuaded to move, but the main body would stay. The best of them are too well satisfied to change. Philadelphia has a body of tool-builders and machinists which gives the city an advantage of a permanent character. She has a vast amount of high-priced labor always at command which cannot be alienated. As a city she can have no competition in this line. Capital will go to her because it will always be able to find the highest skill ready at hand.

The problem to be solved by the manufacturer or capitalist is in its general form a simple one. It is to increase from year to year the earning power of the men employed and to do it in such a way that the men not only earn more but become more profitable to the employer. This is a simple statement, but its application is not always as simple. When the effort is made to carry out the idea in any given industry a very complex problem is generally found to be the result. The task of increasing the earning powers of the men is by no means hopeless. How this was done in one case may be suggestive to others. It was in connection with piece-work in a great manufacturing establishment in Pennsylvania which embraced a great number of distinct trades. As piece-work was the rule, when a man devised any new or improved method of saving time, labor or material, he called for a trial of the improvement. If it was found to be successful a new schedule was made for that class of work. The price was of course reduced but in this way—

the man got half of the advantage and the works the other. Thus the cost of production was constantly reduced and the earnings of the men just as constantly increased. The plan stimulated every man to study machinery and processes. Every operation and every tool was watched with the utmost care by intelligent, interested and jealous eyes. Ambition was at work. There was every incentive for men of skill to stay at the forge or in the machine-shop. Each one felt assured that there was a market for what he had to sell. Every man in the establishment was as interested in cutting down prices as the proprietor himself. Under this very liberal system no limit was placed upon the sum which a man might earn at piece work. It was argued that the higher the wages the more profitable would be the plant. But all improvements did not come from the men. When any originated with the proprietor, the establishment took two-thirds of the saving effected and the men were given one-third.

How profitable this system was may be judged from the fact that a few years ago a certain complex piece used to cost $6. Two or three years later the cost had been reduced by successive improvements in tools, without changing the article, so that it could be turned out for $2.50. The men at the latter price were earning higher wages than before and were still scheming to take off something more from the cost of manufacture.

This general scheme is applicable to a very wide range of manufactures. The principle involved is almost universal in its application. Every employer will find it to his advantage to enlist upon his own side, and virtually take into partnership with him the hope, ambition and self-interest of his men. But a word of warning is needed here. The partnership must be honest, and it must also be fair. It will not answer to gain the men by fine promises and then at the end of the year present the office-boy with the equivalent of one penny per week as his share of the advantages arising from his extra unpaid-for work during the year. No one-sided bargain will be of use to capital or to labor. In the endeavor to make the earnings larger and the profits greater the insincerity of both sides will be among the greatest difficulties to be encountered. When once overcome other obstacles will easily disappear. Then it will be seen that common interest lies in one direction ; that unintelligent greed is the enemy of all. Clear-seeing is the hardest thing to be accomplished. But light has come in some directions, and as the world progresses we may reasonably hope it will constantly move toward the light.

# UNDERGROUND WATERS OF THE ARID REGIONS.

*By Robert T. Hill.*

UNDERGROUND water is too abundant in the East to attract much attention, but in the arid regions of the Western States and Mexico it becomes a matter of the utmost importance. Areas exist there as large as New England—for example, the Llano Estacado—without a stream or permanent pond upon their surface, while other areas, aggregating one-tenth of this whole country, have not a stream with the volume of the Connecticut and are entirely lacking in laterals and springs. Great railway lines, including the Southern Pacific, haul water hundreds of miles for their engines and have spent millions in the search for underground water, and the Government has spent large sums in similar experiments. Most of these efforts have been the result of exaggerated expectations whose non-fulfilment have resulted in the apathy of the people. It was soon learned that the greatest possible use of surface water aided by the best systems of storage could not water a hundredth part of the western area and popular attention turned to the underground supply. Investigation next showed that artesian floods could not be obtained everywhere.

The laws of distribution and utilization of underground waters are as simple as those controlling surface distribution, but the popular fallacies concerning them are appalling—for instance, the erroneous idea that all underground waters flow in streams "like the circulatory system of the human body," supplying every well and spring. It is a curious thing to see the "waterwitch" plod over a farm with his forked stick trying to locate "the current." In the vast area between the Rocky mountains and the Mississippi the belief prevails that all the wells are supplied by the water precipitated upon the mountains which disappears beneath the surface to rise again a thousand miles away along the coastal plain,* while beneath the vast intervening region is an inexhaustible store of water waiting for man's invention to bring it to the surface.

For agriculture in the arid regions underground waters are the only dependence, for surface water, even when used for irrigation,

* *Galveston News*, Nov. 7, 1891, p. 4.

must become earth water before it is available for plant roots; therefore the farmer plows the earth's crust to increase its capacity to imbibe and transmit water. The source of underground water is the rainfall, though the underground supply in any region is not proportionate to its rainfall but is determined by the capacity of the soil to absorb moisture. Of the rainfall, part is evaporated or quickly drained to the sea, while the rest is absorbed by the soil and other rocks. All the materials composing that part of the earth's structure visible to inspection, inappropriately known as the crust, are more or less saturated with water. In arid regions or in times of drought this may not be apparent at the surface, where the moisture is dried by evaporation, but a fresh excavation—a post-hole, a plow furrow, a blast in a quarry or a newly-dug well—will reveal the contained moisture of the earth. This moisture, or earth water, may be scarcely visible or it may occur in great abundance, according to the compactness or porosity of the rocks, the number of fissures, joints and crevices, and their topographic situation.

If rainfall be long continued the portion of the crust upon which it falls becomes completely saturated. Upon cessation of the rainfall evaporation or drying begins at the surface, causing the line of saturation to become deeper and deeper. Thus it is that in the eastern States, where rainfall is excessive and evaporation slow, the line of saturation usually coincides with the surface, while in the arid regions it is often several hundred feet below the surface.

If the earth were of uniform porosity, temperature and composition, the water it contains would be uniformly distributed through it, as is the water in a well-soaked sponge. But this is not the case, for the outer portion of the globe consists of rocks of much greater density than the interior, while the downward percolation of surface water eventually encounters the superheated mass of the earth's interior and either is forced back to the surface as steam, as in geysers and volcanoes, or enters into mineral combinations. Hence the available water is confined to that portion of the earth's crust between the lines of heated interior and surface evaporation. Even in this narrow belt the distribution of water is very irregular. In places holes 300 feet deep can be drilled through soil and rock as dry as powder without reaching the line of saturation, while in New Orleans the water is so near the surface that graves cannot be dug for the dead.

Inasmuch as the arid regions present a vast diversity of geologic structure, the possibility of securing water at any given point must be determined by the local formations. All rocks imbibe water in proportions varying with their physical structure, a fact which can be demonstrated experimentally by saturating familiar types of rock. Glass is similar in water-capacity to large areas of volcanic and other igneous rocks and will absorb no perceptible amount of moisture; marble will drink in a slight quantity, while chalk, sand, and brick will absorb nearly their own weight of water. The manner in which rocks imbibe water is simple. In most rocks, however compact to the eye, there exist interstices, cavities and other spaces in which water may enter and be stored. This is true especially of all sedimentary rocks, which compose 99 per cent. of the earth's crust. A fine sandstone whose grains and intervening spaces may be indistinguishable to the eye, when placed under a microscope, resembles a load of cobblestones in which the spaces occupy as much of the aggregate mass as the solid mass themselves. Into a gallon measure of dry pebbles varying in size from an egg to a pinhead may be poured half a gallon of water. Crystalline rocks, which compose much of the mountain masses in the West, are more compact and less adapted for the storage and passage of water than sedimentary rocks. Nearly all the minerals which compose them are impervious, as is readily seen in a large crystal of quartz, feldspar or mica.

Rocks which have imbibed all the moisture they can contain are in a condition of saturation and all water in excess of this amount will pass off by aid of gravity, capillary attraction or evaporation. The excess above the water of saturation is available as the source of springs, wells and artesian supply. In experiments with these materials each rock will be found to possess a different capacity for the transmission of the water which it has imbibed and the capacity for transmission is entirely distinct from its capacity for imbibition. If the component particles—for instance, the quartz pebbles of a loose conglomerate or the grains of a sandstone—present a smooth, impervious surface, water will cohere to the individual surfaces until the entire article is enveloped in a coat of water. If the interstices are smaller than the average drop of water the resistance of cohesion to the free transmission of water will be greater; hence a chalk or a fine-grained brick will drink in much water but transmit little, while water will pass freely through coarse gravel. The capacity for transmission in variously grained

rocks and the accompanying cohesion is similar to that seen in passing water through sieves of different mesh. Thus some chalks with exactly the same capacity for imbibition as sandstones transmit water six hundred times slower.

These materials with radically different capacities for imbibition and transmission of water have been sorted into definite sheets or strata by the water which deposited most of them, so that another important factor in the question of underground water is introduced—the stratification or arrangement of the rocks relative to one another. Earth-water percolates downward through a porous stratum until an impervious one is reached, while an impervious stratum at the surface will prevent the saturation of a pervious one below. Stratification performs the important function of controlling the distribution of earth-water, of resistance, transmission and storage. If the rock stratum is pervious and horizontal it will simply serve as a sponge to hold the water it receives until disturbed by evaporation or seepage, unless the supply is constantly renewed by rainfall. If an impervious sheet is above an out-cropping porous stratum, it opposes the tendency of water to rise by hydrostatic pressure, and if below, it opposes the force of gravity by preventing the water from percolating to greater depths. If vertical enough, from faulting or folding, the strata cut off the horizontal transmission of underground water.

If strata are inclined, water is transmitted by gravity in the direction of inclination, *i. e.*, with the dip, and, if the topographic conditions are favorable, flowing wells can be obtained at points more or less distant from the outcrop. If the strata incline in a direction opposite to the general slope of the country, no matter how favorable the conditions may be, they will furnish no flowing artesian supply, for water cannot rise above the height of the receiving area. If strata are excessively inclined, as in most mountain regions, artesian wells are improbable if not impossible over any wide area. In folded mountainous regions the strata soon dip below all available boring; hence the generally accepted idea that artesian wells are peculiar to regions of great stratigraphic disturbance is fallacious. A dip of 1 per cent. is hardly visible to the eye, but it will carry a stratum downward 52.8 feet per mile. A dip of 10 per cent., which is hardly noticeable, will carry a stratum 528 feet in a mile. A dip of 45 degrees will carry a stratum deeper in a mile than any drill has yet penetrated.

It may now be said that the most favorable and usual condition

for artesian wells is that of strata inclined at an almost imperceptible angle with the surface slope. This condition prevails in gently sloping basins and not in mountains. Theoretically this arrangement affords a large exposure of the receiving stratum for the imbibition of water and underlies an extensive area in which wells can be obtained. All the great artesian-well areas of the United States are of this type, that of the Atlantic Gulf-coast, of Dakota and of Texas. The receiving area of an artesian system is the area of outcrop of the water-bearing stratum. Its extent is proportionate to the thickness and inclination of the stratum and its value for receiving and transmitting water depends upon the area of its outcrop and its porosity. The outcrop may be of any topographic form, but is usually in a valley of stratification which is topographically higher than the point where the well is desired, as in the artesian areas of Texas, New Jersey and elsewhere.

Most sedimentary rocks occur in definite succession, *i. e.*, sands overlaid by clays and these by limestones, representing the deposits laid down at shore, in shallow water and at the nearer shore or moderate depths respectively ; hence, when a well is begun in rocks of the limestone group a great volume of water must not be expected until several strata of clays are passed through and the basal sands penetrated.

If the earth's surface were a dead level not grooved by river drainage, and were a homogeneous mass, earth-water would sink to the line of complete saturation which would be at a uniform depth, as in a flat undrained field. But the surface is broken into mountains and plains and the plains are scored by valleys ; therefore, through the percolation caused by gravity the line of saturation sinks towards the level of the lowest adjacent drainage valley whose streams are fed usually by the water of saturation escaping at their level. There are two kinds of valleys in the West, stream and basin valleys. The former are the product of erosion through the rock mass caused by running streams seeking base level ; the latter are the filled-in depressions of vast inter-mountain areas like Salt Lake valley of Utah. The stream valleys reduce the line of saturation of the adjacent regions to their level and carry the earth water to the sea. Basin valleys store the surface water of the adjacent mountains by imbibing and retaining it in their loose porous strata.

Topographic irregularities have an important bearing upon the success or failure of artesian wells, but not as great an influence as

is popularly supposed, for the receiving area of artesian districts is more often a level or valley of stratification than a protuberance.

In mountains of disturbed strata (not horizontal), water-level is reduced towards that of the surrounding plain. Mountains in general owe their existence to the compactness and imperviousness of their structure, conditions which render them of secondary importance in a discussion of underground water, since they are quickly drained of their rainfall, except that which becomes crevice water or is retarded by vegetation. Impervious mountains are often important in concentrating the drainage of a large area upon the porous surface of a basin-shaped plain occupying their center. They actually double the underground efficiency of the rainfall for the basins, which fact is of especial value in the Southwest, where the country is of impervious-mountain and porous-basin structure. In the case of buttes and mesas, which usually consist of horizontal strata, the line of saturation is reduced by gravity towards that of the plain or valley which surrounds them.

As a rule, the degree of consolidation of an impervious stratum has little bearing upon its function in artesian wells. Soft clay shale is practically as impervious as a hard slate; hence the incorrectness of the popular idea in the West that a hard rock must overcap the water-bearing stratum. Consolidation, however, does decrease the transmitting capacity of pervious strata, since this power is produced by pressure which decreases the interstitial spaces of the rocks, or by mineral cement which fills the pores. Hence most of the great water-bearing areas are composed either of loosely cemented or unconsolidated sands.

The older formations of the earth are more consolidated, metamorphosed, and disturbed than the newer and hence they occur in but few places in the continuous sheets necessary to great artesian development. The newer rocks (post-Carboniferous) are less consolidated, less disturbed, less metamorphosed, less broken, and are therefore better adapted for imbibition, percolation, and transmission of water. Thus it is that with few exceptions the great artesian areas of the world are in the later formation, *i.e.*, Triassic, Jurassic, Cretaceous, Tertiary and Quaternary rock sheets, which play an important part in the structure of the arid regions of the United States.

A section from the Gulf of Mexico to the Rocky Mountains, say from New Orleans to Las Vegas, New Mexico, will illustrate the principles I have endeavored to explain. From the coast to the

97th meridian is a large series of porous sheets of strata inclining with the surface at only a slightly greater angle. This represents, with one or two exceptions, the condition of the entire Atlantic seaboard. These strata constitute the rocks from the latest Jurassic to the present time and represent a series of ancient coastal deposition plains; nearly everywhere throughout their extent artesian wells are obtained, from New Jersey to Texas. This series rests upon another of older rocks which incline to the westward and opposite to the topographic slope, and outcrops between the 98th and 101st meridians. No successful artesian wells of large volume have been or are likely to be obtained in this region. A similar negative condition exists in that portion of northeastern New Mexico which I have termed the Las Vegas plateau; experimental wells of great depth have been drilled without success at Trinidad and Las Vegas.

The principle that greatly disturbed or mountainous areas are not favorable artesian areas is illustrated in the dip of the strata of the Rocky mountain front south of the Arkansas, the excessive angle of which almost immediately carries them beyond the reach of man. The influence of structure and imbibition is shown in the basin plains of the West. These vast stretches constituting all the level land of the arid region have been looked upon by the professional geologist as unworthy of experimentation for artesian water, owing to the absence of consolidated strata and the prevailing fallacious idea that the "upturned edges of the adjacent mountain regions were the receiving area of all underground water." Although unconsolidated, the rocks of the basin plains are alternations of porous and impervious beds and hence are valuable artesian areas; by experimentation in boring in properly-selected sites considerable water may be obtained. Non-flowing wells have been secured in many of the most unpromising plains, even in Death's valley; as furnishing water for live stock these wells are very important.

In conclusion it is well to consider the application of these principles to obtaining underground water in the vast arid regions of the United States and Mexico. First, it is apparent that the best conditions for securing underground water are not in consolidated or mountain rocks, as shown by the futile experiments of the Government well-borings under Captain Pope in 1858, and the numerous failures of the Southern Pacific railway—all of which were drilled with the idea that the earth-water came from the

mountains. But, on the other hand, the most sterile sandy upland plains—for example, the Jornado Muerto—or filled-in river valleys like that of the Rio Grande, are most favorable locations for imbibition and storage of underground water.

By taking advantage of this law thousands of wells, nonflowing it is true, have been obtained upon the greatest of our supposed waterless plains, as the Llano Estacado and the Franklin Hueco basin north of El Paso, and numerous flowing wells have been obtained in desert basins, as in Salt Lake valley in Utah, in Colorado and in California. The supply of underground water is sufficient to reclaim for agriculture by irrigation only a small fraction of our desert lands, yet by application of the principles above mentioned many wells can be obtained upon areas now absolutely worthless. The water would be of great value to overland commerce and to herders, and would save large amounts of money now wasted in unprofitable experiments.

# RIVER IMPROVEMENT AT PORTLAND.

*By George W. Freeman.*

PORTLAND, the commercial metropolis of the Northwest, is connected with the ocean by one-hundred-and-ten miles of river—that is to say, ninety-eight miles of the Columbia and twelve miles of the Willamette. Built upon both sides of the Willamette, at the head of deep-water navigation, assured of its prosperity and possessing great wealth, Portland naturally is desirous that all products and commodities imported to, or exported from, her port shall have every advantage of cheap transportation.

During the year ending June 30, 1891, the value of the exports from the Columbia river was $6,089,585, and the value of imports $1,325,400. In the same year the deep-sea tonnage passing in and out over the bar, at the mouth of the river, was 1,923,818 tons; this with the local tonnage makes over 3,000,000 tons for the Willamette and Columbia rivers between Portland and the sea. The total custom-house receipts were nearly $650,000, and the jobbing trade of Portland for 1890 is estimated to be $131,550,000.

The demand for an unobstructed deep-water channel has kept pace with the growth of the city and the development of the tributary country. Prior to 1866 the depth of channel at the shoalest places, at low water, was from nine to twelve feet. Vessels loaded deeper than that were compelled to take advantage of high tides and high-river stages. In many cases vessels were lightered of their cargoes some twelve or thirty miles below the city in order to allow them to pass over the shoals above.

The first efforts of the Government at this port were directed toward securing and maintaining a channel to the sea of fifteen feet at low water, which was no sooner accomplished than a demand for eighteen feet was made, followed by one for twenty and finally for twenty-five. Since 1866 the Government has spent in improving the Columbia and lower Willamette rivers about $890,000, making an average of $35,500 per year. This improvement consisted of reveting the banks, diking across sloughs, constructing contraction works, and dredging. There is no doubt that better results would have been obtained had the whole of the amount been available at once, yet in 1881 the benefits of these works were

such that, assisted by the dredge, the least depth at extreme low water throughout the whole distance was nineteen feet.

Before the construction of the jetty at the mouth of the Columbia river was commenced the ruling depths over the bar were from nineteen to twenty-one feet, but in consequence of this jetty, nearly completed, there is now at low water a depth of twenty-eight feet, and every prospect of thirty feet in the near future. With this increase of depth on the bar the deepening of the river becomes imperative in order to allow deep-draft vessels to charter direct to Portland.

The River and Harbor act of September, 1890, directed that a project with estimate of cost, for obtaining such channel between Portland and the sea, be submitted. This duty was assigned to Major Thomas H. Handbury, Corps of Engineers, U. S. A., the officer in charge of the improvement of these rivers, and in due course of time the maps and plans were forwarded to Washington, where they were approved.

In this reach of one-hundred-and-ten miles of river there is an aggregate of ten miles that needed to be improved—four miles in the Willamette and six in the Columbia. Commencing at Portland and proceeding down stream the localities needing improvement are as follows: In the vicinity of the head of Swan Island, between the lower end of Swan Island and St. John, Post Office Bar, St. Helens, Martins Island, Walker Island, Cathlamet Bay, and near Upper Astoria. Reference to the general map will show the relative locations of the above-named places, while the other maps will show the characteristics of each.

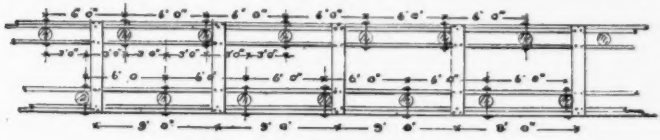
A study of the surveys made of these localities reveals the cause of the shoal water, and also suggests the general principle on which the plans of improvement were based. In the Willamette, wherever the width of the river exceeds 1400 feet between low-water lines, we find less than twenty-five feet at low-water. In the Columbia, wherever the width of the river exceeds 4000 feet between low-water lines, we also find less than twenty-five feet at low water. The one exception to this rule is in Cathlamet Bay from its head to the ocean; here the excessive width, about six miles between banks, pertains with numerous sandbars, while the ebb and flow of the tide plays an important part in determining the location and depth of the channel.

Two-thirds of a mile above Swan Island the width of the river is 4000 feet, the average depth nineteen feet, and the maximum

A VIEW OF PORTLAND, OREGON.

SHORE END OF WALKER ISLAND DIKE—BANK PROTECTED WITH FASCINES NOT YET COVERED WITH ROCK.

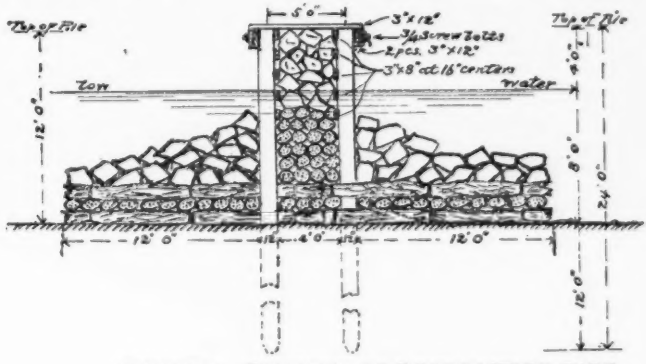
thirty-four feet. A quarter of a mile nearer the island the maximum depth is twenty-five feet, with a low-water width of 1600 feet, and here we encounter the first difficulty. At the head of Swan Island the width between low-water lines is 3800 feet. The island divides the river into two channels. The south channel is wide and shoal, having about two feet at low water. It has shoaled gradually and is now practically a high-water chute. The north, which is the main ship channel, is narrow, but of ample depth after passing the head of the island. To improve this place a dike four feet high



GENERAL PLAN OF TIMBERING

above low water, and 6800 feet long, joining the head of the island with the left bank of the river, was built by the Government. The building of this dike diminished the sectional area at a four-foot stage about 44 per cent., and throws about 43 per cent. more water down the north channel. The increased velocity due to the contraction and concentration of the river has already had its effect in keeping the channel open, but to assist the erosion of the river the dredge has been resorted to.

The next locality at which is found an excessive width of river and with a depth less than twenty-five feet is between the foot of Swan Island and St. John. The width of the river at the foot of

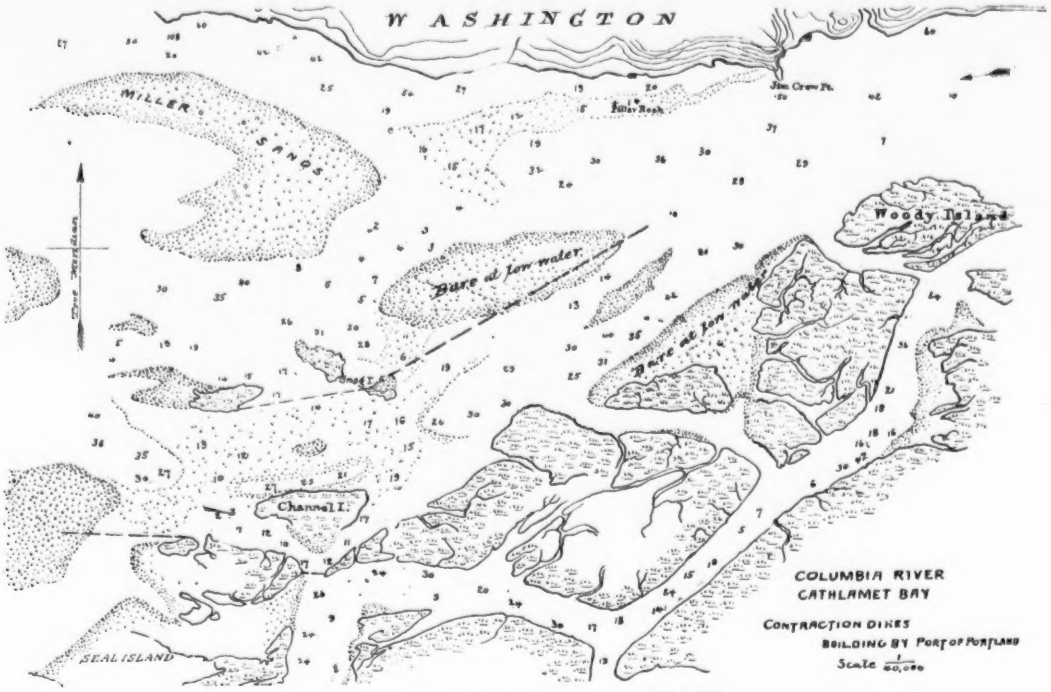


GENERAL SECTION OF CONTRACTION DIKE

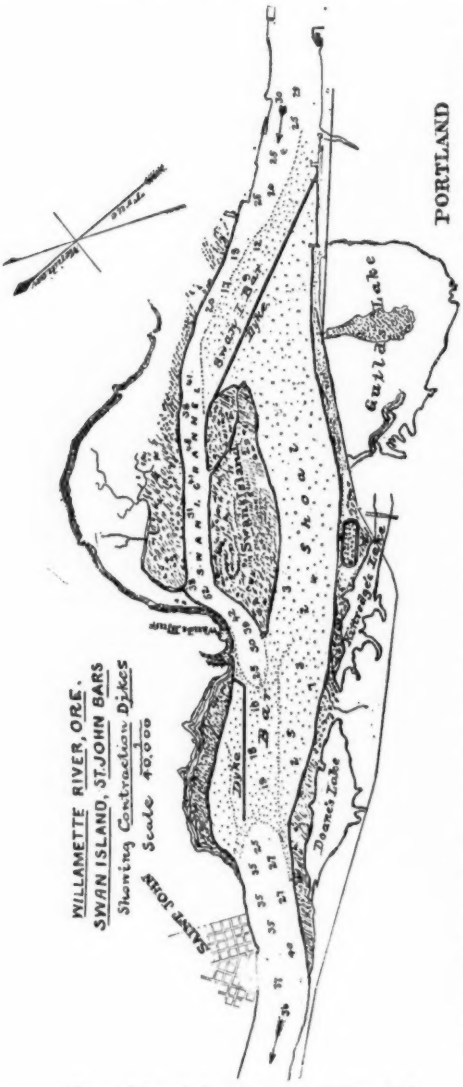
the island is 2400 feet, but the velocity acquired by the river while passing through the north channel is sufficient to maintain a channel of twenty-five feet for a distance of about half a mile below the end of the island. At this point, however, the force becomes expended, and the tendency to spread over the excessive width results in the formation of the shoal. To improve this a dike about 4000 feet long was recommended, commencing at a point about 2000 feet below the end of the island, and after extending 500 feet from the right bank to incline down stream, keeping in about twelve feet of water, the dyke to be four feet above low water, and the action to be hastened by dredging.

GENERAL MAP OF THE COLUMBIA AND WILLAMETTE RIVERS

Farther down stream is Post Office Bar, caused as above by the excessive width of the river, and also the diversion of a portion of the water down Willamette slough. On account of some commercial interests this slough cannot be wholly closed, and an opening 150 feet wide to allow the passage of river boats has been left. The improvements, as recommended, consist of a spur dike built perpendicular to the right bank of the river 1000 feet long, near the point where the 25-foot depth ceases, on the upper side of the bar; a second spur dike 600 feet long, 1000 feet below the first, and on the same side of the river; and a third, still on the right bank 1200 feet below the last. This third dike, after leaving the shore, to extend




MAP SHOWING BY DOTTED LINES THE CONTRACTION DIKES.




across Deer Island shoal is recommended.

down stream and about parallel with the left bank of the river for a distance of about 4000 feet.

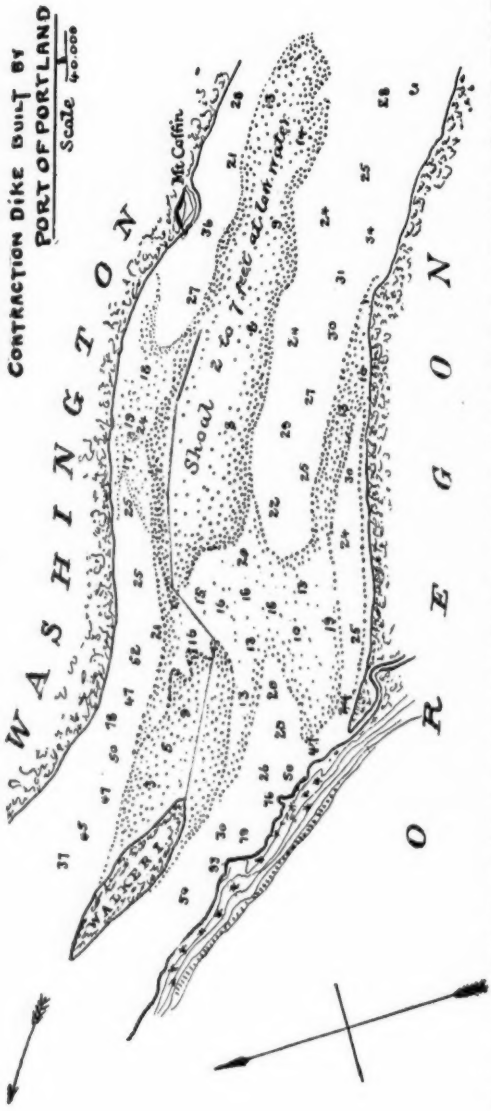
We now enter the Columbia and proceeding down that river fourteen miles come to St. Helens bar. Here the Government has built a permeable jetty 5500 feet long, which is doing good work, but in order to fully maintain a channel twenty-five feet deep, some additional filling of the jetty with rock and brush will be necessary. Three miles below is Martins Island bar where the river is 6000 feet wide. About one-tenth of the volume of the river formerly passed through Burks and Martins sloughs on the right, but these have been closed, and already the result of this improvement is felt. To hasten matters a dike about 2000 feet long extending from the left bank

Twenty miles down the river is Walker Island, where the river is 6600 feet wide, with three channels extending through this reach, none of which afford the required depth of water. From Mount Coffin one passes down the Washington shore, to the east of Walker Island, a second down the Oregon shore to the west of the Island, and the third across the head of the Island joining the east, or Washington shore channel. This last channel has a ruling depth of sixteen feet. The tidal flow without doubt has considerable weight in determining the depth of these channels, the mean rise being 3½ feet. To improve this place it was recommended to construct a longitudinal dike parallel with the Washington shore, at a distance from it of about 1600 feet, extending from near Mt. Coffin down to the middle channel, thence obliquely across the channel, thence to the head of Walker Island, being in all about 12,000 feet in length. The object here is to build up the shoal in the middle of the river, thus reducing its width, or in other words to extend Walker Island up stream.

Below Walker Island there is plenty of water until Jim Crow Point in Cathlamet Bay is reached. This point is about twenty-six miles from the bar, and the river here commences to widen rapidly; through this reach there are numerous shoals, separated by channels of varying depths. Here it was deemed best to obtain the required depth of twenty-five feet by the most practicable and economical route, and to disturb as little as possible the present existing conditions. It was determined therefore to restore and maintain the channel passing to the south of Snag Island, by means of training dikes, aggregating about 19,000 feet in length, the locations of which are on an accompanying map. It was not deemed advisable to locate any permanent work with a view of controlling the water below this point, until those further up the river have been built and their effect noted.

The total amount of diking necessary to construct the works just enumerated is about 50,000 feet, the dredging amounting to more than 1,000,000 cubic yards, with a total estimated cost of $772,464. The Government, however, was out of money, only enough remaining to construct the dike at the head of Swan Island.

In February, 1891, the Oregon Legislature passed the Port of Portland bill. A corporation was created to be known as the Port of Portland, its affairs to be administered by a Commission composed of fifteen of the first business men of the then three cities of Portland, East Portland and Albina, but now included in con-




solidated Portland, its object being the improvement of the lower Willamette and Columbia rivers from Portland to the sea. To do this the Port of Portland was empowered to issue bonds to the extent of $500,000, to levy a regular yearly tax of not over three tenths of 1 per cent. on all property within its boundary, and if necessary a special tax in cases of emergency. It was tested as to its legality by a friendly suit and declared constitutional and valid by the Supreme Court. The Port of Portland has obtained permission of the War Department and has undertaken to make most of these improvements. It was decided to first

construct the works on the Willamette and at Walker Island, as these were the places demanding the most attention.

The writer assumed his duties as Engineer of the Port on November 1, 1891. Bids to construct these works were asked for and opened on November 19. To facilitate matters the work was divided in three parts, St. John, Post Office Bar and Walker Island. The bids were so much per unit for each article in place, for instance: per lineal foot for piles, per cord for fascines, per ton for rock, etc., the contract to be awarded to the lowest responsible bidder for the whole of the material in place. Work was commenced about December 1, and practically finished about May 20, 1892. There yet remains some little finishing touches, to make the dikes complete, but these cannot be done until the present high water recedes. The total amount of diking in the three localities amounts to 22,350 feet, aggregating in cost $150,000.

The manner of constructing the dikes is as follows: Two rows of piles four or five feet apart, according to the depth of water, were driven not less than twelve feet into the ground and cut off four feet above low-water level. The piles in each row are six feet apart, and each pile is opposite the center of an interval in the other row. The piles in each row are connected by a horizontal waling piece, made of two thicknesses of 3" x 12" planking, bolted on the outside of each pile. On the inside were placed four or less rows of 3" x 8" planking spaced eight inches apart and spiked to each pile. The two rows of piles were secured to each other by cross braces spiked on the top of the waling and distanced about nine feet to prevent the rows from spreading after filling the interval with brush and rock. The fascines were made of fir or willow brush tied in three places, and when complete were 16 feet long and 9 inches in diameter.

The piles were first driven and followed closely by the brush-mats and filling. The lower or foundation mats were made in lengths of about 80 feet and upon floats on each side of the dike. The brush was first laid from the scows on the floats and perpendicular to dike, the inside ends overlapping; these were firmly bound together at the ends and center with wire, three men doing the binding. Another course was then laid on perpendicular to the last, and also firmly bound, and so on until the desired thickness of mat was made. As soon as the mats were completed the floats were removed and another commenced. The advantage of this method of making mats over the old one made in short sections and with poles, was the

ease with which they were sunk, the mats being so firmly bound together that the sinking of one side naturally carried the other side and center down also. Those who have had experience with short mats will remember how difficult it was to sink them, as any unevenness of loading caused the mat to upturn, spilling its load, and in many cases losing the mat altogether. Mats as described above have been built by the writer over six feet thick and sunk in eighteen feet of water with a strong current running at the time, without losing a bundle. Between 375 and 400 feet of these mats, three fascines thick, were built in a day. Wherever the dikes joined the shore the banks were protected by first grading the bank at a slope of 2 to 1 and covering the same with brush and rock.

The works above referred to were built so cheaply that bids were asked on the Snag Island work. When opened, the lowest was about half the estimated cost. These works are now fully under way and progressing finely. The City dredge of the elevator type was used to aid the contraction works then building in the Willamette and Columbia. During the season just closed nearly 100,000 cubic yards were removed at a cost of 11.06 cents per yard. The long-desired 25-foot channel between Portland and the sea is fairly in sight and that Portland is a deep-water port is proved by the recent visit of the United States cruisers *Baltimore* and *Charleston* to this port. They passed up and down the one-hundred-and-ten miles of river without difficulty.

# THE RAILWAY OF THE FUTURE.

*By Oberlin Smith,*

*Past President Am. Soc. Mechanical Engineers.*

THAT the railway system of the present is destined to a more rapid rate of development than in the past is one of the signs of the times. Splendid as is its record, it is guilty of killing and wounding somewhere near 33,000 people per annum in the United States alone. It carries its passengers at an average speed of only about twenty-five miles an hour, and it burns extra coal enough to carry with each one an average dead-weight of from one to two tons, running up to six tons in some classes of trains.*

For the attainment of the highest perfection in the three things which railway passengers most desire, safety, speed and cheapness, we must institute certain radical and sweeping reforms. In carrying these out, the most important features to keep in view for securing safety would be some system of practically non-destructible track, on which the wheels could be confined mechanically, and the cars or trains kept blocked a proper distance from each other. For speed and economy we must have a lightening of the cars, upon principles and to a degree which have never yet been attempted in the construction of any vehicles except bicycles and tricycles.

For such track construction, that is for absolutely non-derailable cars, a metallic tunnel obviously forms an ideal road-bed, inasmuch as a car can be confined therein as surely as can a piston in its cylinder. The same general principle (of holding a car down otherwise than by the present system, of ballasting with unnecessary weight) can obviously be applied to an elevated road, but not successfully to any sort of a surface road with grade-crossings or other interferences. Our future railways will embody both the over- and under-ground methods, as circumstances shall dictate. In favor of tunnels it must be remembered that they lose much of their unpleasantness when brilliantly lighted by electricity, and when no fire, smoke, steam, water or gas is permitted within them.

In designing the non-derailing roads of the future, it is evident that one of the enormous difficulties to be overcome will be how to manage switching from one track to another, or, preferably, how to abolish switches altogether. These are not, however, unsolvable

* For an analysis of train weights, see an article by the writer in *The Forum*, Jan., 1891.

problems. An incidental advantage of an unbroken track is its adaptability to some system of grip track-brakes, whereby fast-running cars can be stopped in distances much shorter than where mere wheel-stopping is depended upon.

To the student of this subject a dozen years ago, it seemed possible, by sufficient care and expenditure, to make a railway almost absolutely safe and comfortable, but in the attainment of very high speed there arose insurmountable difficulties, chiefly on account of certain limitations in the locomotive. There were, it is true, rumors in the air of electric railways abroad, but few American engineers would have risked their reputation for sanity by seriously expressing an opinion that a new era of propulsion was dawning. So rapid, however, have been the strides of electrical science that the mist of doubt is cleared away, and looming up in the clear atmosphere is a newly-created warlike steed, with fire in his nostrils, who has already slain his thousands of street-car mules, and is panting for a fray with the great iron horse himself.

Recent statistics tell us that there are now running, in the United States alone, nearly 4000 electric street-cars, upon 2000 miles of track, with as much more similar plant in course of construction. These cars run faster, more cheaply and under far more perfect control than do their predecessors, the horse-cars. In America this system of propulsion is commercially but four or five years old, and is barely out of its experimental stage; yet it is a magnificent practical success—with more than $50,000,000 invested in it—and this under some of the worst conditions possible for railway work. Some of these conditions consist of very narrow wheel-flanges; rough tracks, obstructed with water, snow, mud, gravel and foreign vehicles; curves as sharp as thirty feet radius, grades as steep as 12 per cent. etc. A service more nearly re-rembling that of our present steam-roads is that performed by the City and South London Railway, which is practically the first underground electric road in the world and is already a great success, having during the eighteen months of its existence carried more than 7,000,000 people, with a run of over 500,000 train-miles. Although not entirely perfected, a road like this forms one of the notable object-lessons by which we are learning how to travel.

In the light of such experience there is no question whatever about the success of either a subterranean or an elevated electric road, if properly designed to meet the new conditions involved—and the running may be at *any speed* which can be made safe. We may,

therefore, in our further study of the ideal railway, positively leave out of the question the steam-locomotive. Great as have been the performances of this wonderful and beautiful monster, he not only refuses to climb very steep grades but he has utterly failed, in the matter of speed, to keep pace with his improved behavior in other respects. In proof of this we have records of English engines going at the rate of 75 miles an hour, forty years ago; and that is the maximum work of our present machines, although they may have occasionally touched a 90-mile rate as a phenomenon.

Until quite recently regular railroad-men have been inclined to smile at the mention of electric propulsion, but a great many of them now admit that it is probably the proper thing for elevated lines and other special constructions. Comparatively few, however, are yet ready to accept the probability of electricity displacing steam upon the ordinary railways already in existence. These, who are among the most progressive in our great corps of railway managers, are carefully watching developments, and stand in a waiting attitude ready for whatever revolution may come. The electrical engineers, as a rule, are quite sanguine about the future use of the electric current on all classes of railways, and they are naturally proud of the great achievements that have already been made in street-car service. The attitude of mechanical engineers in general is one of doubt, especially as regards the ordinary railway. Several carefully-studied papers have been written lately with long arrays of figures which, in their authors' estimation at least, respectively prove both sides of the argument. The writer confesses that he has hardly made up his mind upon this difficult question, but he inclines to the opinion that the experiment will be tried in the near future, and that it will result in a fair measure of success, especially if the cars are made lighter. We cannot, however, expect extremely high speeds with our present form of roadway, on account of the liability to derailment and collision with foreign vehicles.

A question which has been agitated a good deal among engineers who admit the desirability of electric propulsion in general, is whether a train shall be drawn by a so-called electric locomotive, or whether each individual car shall be made self-propelling, by having the electro-motors upon one or more of its axles. There are many who favor the former method, but it is difficult to see why—unless because it is a less radical departure from the old system. The arguments in the case of steam-propulsion are all on

one side of this question, and absolutely show the necessity for a separate locomotive, it being entirely impracticable to divide up the boiler and engine, with their complicated mechanism and the necessity for skilled attendance, among a number of separate cars. Fortunately the heavy load which it is necessary to carry, in the shape of fuel, water, boiler, etc., gives nearly enough weight for traction purposes—that is for the friction necessary to keep the wheels from slipping on the track; although there are frequent exceptions in the case of wet rails and up-grades. If we could do as the old woman in the story advised the Mississippi steamboat captain to do, "bile our water on shore," and if, furthermore, the steam thus generated could be picked up in small quantities as it was wanted, along the track, and could be used in a small simple rotary engine attached to each car-axle, then the best course might be to abolish the locomotive and run the cars as self-propellers.

In using electricity we have just the conditions that we cannot have with steam: a rotary motor which is as simple, as far as its motions are concerned, as a churn or a grindstone; which can be mounted upon or geared to the car-axles direct; which requires but little or no attention while running and which picks up the current of electricity that drives it by a simple wire connection, as it progresses along the line. Furthermore, this electricity can be generated in stations located at proper intervals along the route, where the water is boiled "on shore" to run the great engines which produce by means of dynamos the required current. This water, moreover, is boiled with a far greater degree of economy than it possibly can be in the locomotive, with every advantage in saving of fuel and attendance which can be gained by large triple- or quadruple-expansion condensing-engines. The great economy thus obtained in coal consumption will undoubtedly go far to offset, if it does not entirely overbalance, the loss of electricity by waste along the line, and by a certain inefficiency in the dynamos and motors.

One of the most obvious advantages of this system being the absence of any real necessity for a locomotive, it would certainly seem very foolish to nearly or quite double the total dead-weight propelled by building such a machine, and ballasting it with enough iron or brickbats to get the necessary traction, when each car can itself carry the required simple motor mechanism; and when, with its own weight and that of its passengers, no matter how lightly it may be built, it will be sufficiently heavy for tractile purposes.

A peculiar and valuable feature of electrical propulsion is the

ability to frequently dispatch short trains, or single cars, with as great economy of power as long trains—each car being able to select, at each instant of time, the exact amount of electrical energy needed for moving itself and its load, and this at any inclination of grade that it happens to be upon. Besides, the adaptability of the current to its functions permits a car under some circumstances to be braked electrically, in which case it is possible to repay power to the general fund, instead of wasting it in brake friction.

It is of course unlikely, for very many years to come, that there will be any radical change in the road-beds of the vast net-work of our existing railways, except in the matter of stronger tracks and bridges, and the avoidance of grade-crossings and some other evils which are now being reformed upon our richer lines. Such reforms will bring them only to the high grade of efficiency and safety already existent upon the English and some other foreign roads. It is probable, however, that some form of highly-organized elevated railway, built with scarcely any regard to the saving of first cost, and with a vast amount of dead-weight in the track, rather than in the rolling-stock, will before many years be built upon some route where the traffic is large enough to pay the interest charges on an enormous first cost, in addition to meeting the comparatively light running expenses. This road will be so built as to make derailment impossible ; will be without switches or crossings ; will have running upon it, driven by electricity, light narrow cars, either singly or in short trains, which will be sharp in front and smooth upon the sides, after the manner of a bird, in order that air-resistance may be reduced to a minimum. If, as is probable, the electricians succeed in perfecting an electric block-system (something that has been already experimented with in England by the lamented Professor Jenkin and others) which shall make it physically impossible for one train to approach another, either before or behind it, within a pre-determined distance, then there need be no speed limit except that due to the requirements of not braking a car so rapidly, within a given available stopping distance, as to throw passengers violently from their seats.

The actual speed which will be obtained is of course extremely problematical as yet, but there seems to be no inherent mechanical reasons why we should not, on long and absolutely clear stretches of track, obtain a velocity approaching two hundred miles an hour. There will of course be no drawbridges or other artificial gaps, and everything about the roadway and its foundations will be built with

such an enormous surplus of strength, toughness and rigidity that no ordinary causes can possibly disturb it. The cars of this ideal track will be so confined that they cannot leave it, even should their wheels and other machinery be entirely broken up. Such machinery will of course be made of the toughest material, but will be so placed as to do little damage should it meet with accident due to hidden structural weaknesses.

These cars will be so lightly built that the coefficient of dead-weight will be very small, and the stopping and starting quickly will be, even at the high speeds attained, a comparatively easy matter. The old-fashioned notion that the power required to move a vehicle is as the square of the speed has in recent years fallen into disrepute, and although we have not yet made sufficiently definite experiments to accurately formulate a law concerning this matter, it seems tolerably certain that while the air-resistance may approximate this rate of increase, it will not entirely follow it, if the front of the train is shaped to properly cleave the atmosphere. The other resistances, due to friction, etc., probably increase very nearly as the speed, and will, therefore, cause but little more loss of power at a high than at a low speed, when a given distance is considered. What refinements our inventors may attain to in the way of roller bearings, as they have already done in the bicycle, and what they may do in the way of guiding the car sidewise by rolling friction, rather than by the grinding friction of wheel flanges, we cannot yet determine.

The cars in question will of course be lighted, and probably heated, by the same electric current which drives them. If it should prove practicable to use rubber tires upon the wheels it is easy to imagine the delightful smoothness and quietness with which they will run—and this through air untainted with sand, cinders or steam-whistles. If, to secure lightness, they are not fitted with as many hotel conveniences as are our present "Pullmans," it must be remembered that the trips will be so shortened that the want of them will scarcely be felt, at any rate upon routes of moderate length.

To make the high speeds referred to practicable, curves will be avoided as much as possible, and when they do exist they will be made of the greatest practicable radius. This method of line location will, however, be favored by the elevated form of construction, and by the fact that it will not be necessary to pay so much attention to avoiding grades as is the case with our present roads. Not only, as before stated, can an electric car mount a much steeper grade than we now deal with, but from the inherent nature of this

method of transmitting power it is possible (though the principle is not yet fully developed) to brake a car electrically upon a down-grade, so that for the time being its motor becomes a dynamo. This generates an extra current and restores it to the line, which in its turn supplies some of the necessary excess of power at the up-grades. Thus a track may undulate up and down to a considerable extent without the disadvantage of great loss of power inherent in our steam railways. This principle will therefore favor the arching upward of bridges in mid-channel, for clearance of boats, without elevating the approaches to so great an extent as is now done.

In regard to the location of the pioneer railway of the type indicated, it seems reasonable to infer that it will be built either between London and Liverpool or between New York and Philadelphia—for the reason that the traffic is probably of greater volume, upon these routes than anywhere else in the world. It is not likely, however, that sufficient capital could be procured at the start for so large an experimental investment as would be required to build, for instance, the whole ninety miles between the last-named two cities. It would seem better that a small portion of such a line should be built first, but long enough to give a proper trial to the high speed desirable, without spending all the time in starting and stopping. It may be that when one of the proposed new bridges is built across the Hudson river the best place to try the first section of this "railway of the future" would be from the heart of New York city to some central point in a busy city like Newark, keeping in mind an open route for the future as an extension to Philadelphia.

Should a few hundred miles of such a road as this be built, and become a success as regards safety, comfort, speed and economy, as undoubtedly it eventually will, after sufficient experimenting, the new system would gradually spread throughout the world, obviously concentrating itself at first about large cities where the traffic was sufficient to warrant the expenditure. The lessons learned by such a system of transportation would enable the ordinary roads to adopt many of the new principles involved, and we should see a gradual evolution of new methods, leading to changes of which we now can scarcely dream. These changes would spread gradually away from the large cities to the more thinly-populated country districts. They would at first affect passenger lines only—the old roads, with their old methods, being kept mainly for freight purposes, and perhaps for local short-distance passenger traffic. The

new principles and methods would probably eventually extend in whole or in part to freight traffic also.

It is difficult now to say how the changes indicated will come about, whether by a comparatively slow process of evolution, adding improvements little by little to our present methods, or whether capitalists will be found with sufficient nerve to precipitate the sudden change of methods which our rapidly-gained electrical experience would seem to call for. If it be asked how the actual work is to begin, the answer is: by the earnest coöperation of a body of engineers and scientists, backed by a syndicate of bankers. Such a great work cannot, if it is to prove successful, be left to a few individuals, or to an ordinary company whose sole object is to build as cheap a structure as possible upon which to run their trains. The matter should be taken up by a powerful syndicate of capitalists, who should employ a commission of the ablest engineers available. This commission should not be composed of railway engineers alone. Such men, although perhaps of great ability in practically constructing and managing our present systems, are educated too much in conventional grooves to take the broad view necessary in instituting so radical a change of methods. In their defense it should be said that it is their business to be conventional, and their employers, the railways, could not afford to have them otherwise. There should be, however, enough of them in the new commission to give ballast and conservatism. Then there should be thoroughbred mechanical engineers, with an eye to all possible constructions based on correct principles, no matter how novel the form. There should be a sprinkling of professional inventors to give originality, and last, but not least, a corps of electricians of the highest standing, especially in regard to practical experience in street-railway work. That it is possible for such a body of men to devise something better than our present system, at any rate for special locations, is a matter hardly to be doubted.

If we may judge by the wonderful stories occasionally appearing in the daily newspapers there are already some schemes on foot, for extremely rapid transit. They seem mostly to be based too nearly upon old forms of road-bed, or else to have run wildly to some absurd extreme. They all appear to be in harmony however, in regard to making the cars too heavy and the track too light and cheap. Furthermore, some of them are located at ground level, which would of course be fatal—in more senses than one.

It is hardly necessary to touch upon the great importance to the

traveling public of far higher speeds than we have been accustomed to conceive of as practicable. There are now carried by the railways between New York and Philadelphia not far from 5000 people every day, besides all of those who travel only a part of the distance. This is about 1,825,000 through passengers per year. If the time spent in these journeys could be shortened from an average of say 2½ hours to a little less than one hour, the saving to the passengers would be three million hours ; and this with a speed only a little more than 100 miles per hour. If we value the time of these people at an average of twenty cents per hour we have $600,000 saved annually—or the interest at 5 per cent. on $12,000,000. Should it be found practicable to make two or three stops *en route*, these figures would be largely increased by the way travel.

What extra fares the passengers would be willing to pay for this fast service it is difficult to predict. Such a radical change in the speed and convenience of travel would however cultivate and enormously augment the *traveling habit.* Not only would many classes go much oftener than now, because of the time saved *in transitu*, but because of the convenience of being able to start at such frequent intervals, as say, ten, fifteen or twenty minutes. Of the social and commercial changes that will be brought about when a New Yorker finds Philadelphia practically as near as are Brooklyn or Hoboken now, we can at present form no adequate conception.

The number of passengers traveling locally both ways between New York and Newark is not far from 16,000 daily, and is constantly on the increase. Such part of this number as could be tempted to take an eight or ten minutes spin (when there is a bridge built) instead of going by the old routes, would form a nucleus of patronage which would be worth considering. It would therefore seem probable that this location is destined, perhaps long before the twentieth century shall dawn, to be the scene of an experiment which will inaugurate the New Era in railway construction and operation.

In regard to the future development of travel by rail, there can be no doubt that it will be largely stimulated by all improvements which tend to make it safer, more rapid and cheaper. The recent wonderful increase of patronage upon the Hungarian railways, due to the adoption of the "zone system," wherein the fares are not only cheaper, but simplified to an extent that appeals to the imagination and excites a desire to ride, is a lesson that we shall sometime heed. Something of the kind may in this country be destined

to do for our passenger traffic what cheap and uniform postage has done for our letter-writing—especially if we can contrive some way of managing our railways as a unit, and thus get rid of the loss and waste due to competition and litigation. It would be interesting to know the effect that would be produced upon our volume of travel if we could combine with some of the mechanical advantages indicated in this essay an absolutely uniform mileage ticket, to be bought anywhere like a postage stamp, at, say, one cent a mile, and good at any place and time until used. When we combine with it the coming 24-hour numeration of time (which has already been adopted by The American Society of Civil Engineers and by several railway companies in this country, as well as by the Governmental railways of India) and some simple system of universal time-tables, the traveler will begin to be relieved of the brain and nerve stresses which now add so much to the fatigue of his journeying.

It must be remembered in favor of the general reform herein predicted, where an enormous investment in permanent-way allows safety and rapidity of motion in rolling-stock, with cheapness in its construction and operation, that volume of travel, and consequent income, can be almost indefinitely extended without very much increase in interest charges. This is especially true with extremely high speeds, on through lines, because a great many trains, or single cars, may be upon a track at once and yet be "blocked" a sufficient distance apart for safety. The principal increase of expenses is obviously for the cars themselves, for attendance thereon, and for the comparatively small amount of power required to drive structures so lightly built and running so easily as the steel-aluminum-rubber-leather-paper passenger coaches of the new *régime*.

If we look about us for the need and manner of the improvements indicated, we find that our methods of travel need reforming; hence the *Why*. The experience of three-score years and the scientific knowledge of to-day, personified in the engineers of Europe and America, will show us the *How*. Shall not the last decade of this century of science show us the *When?* Are our capitalists ready with the *Wherewithal*, spending their money that more may come, and crowning with laurels their own brows as the men who first nurture into vigorous life-buds and blossoms that shall ripen later into the full fruition of the "Railway of the Future"?

# GOLD-MINING IN THE BLACK HILLS.

*By Harry M. Hanson.*

IT would be difficult to exaggerate the marvelous wealth of the Black Hills country. Marvin Hughitt, the well-posted president of the Chicago and Northwestern Railway, than whom no one has had a better opportunity to know whereof he speaks, has declared the territory one hundred miles square, comprising the Black Hills, to be the richest spot of like dimensions on the globe. To the outside world the Black Hills are known chiefly for their production of gold and silver, and lately as being the site of certain tin mines, the condition of which has been hedged about with so much mystery as to confuse beyond measure the average reader.

The Black Hills interest has been developed in the face of obstacles any one of which would have been the death-knell to a country less richly endowed with mineral wealth. In this region the last determined stand was made by the savage aborigines; the gold-hunters risked their lives to reach the mines, and it was years before the Hills became a safe place for either living or "prospecting." After the war-whoop had died from the hills and valleys, and hostile bands had ceased to molest immigrants on the plains adjoining the foot-hills, the cost of transportation was so high as to prove almost as effectual in keeping away settlers as the bullets of the Indians had been before. Now, however, two trunk-line railroads have penetrated the Hills, and two narrow-gage systems wind up the valleys and ravines, cross the cañons and climb the hills, together affording the facilities heretofore so sorely needed, and bringing the Black Hills, with rapid strides, into prominence.

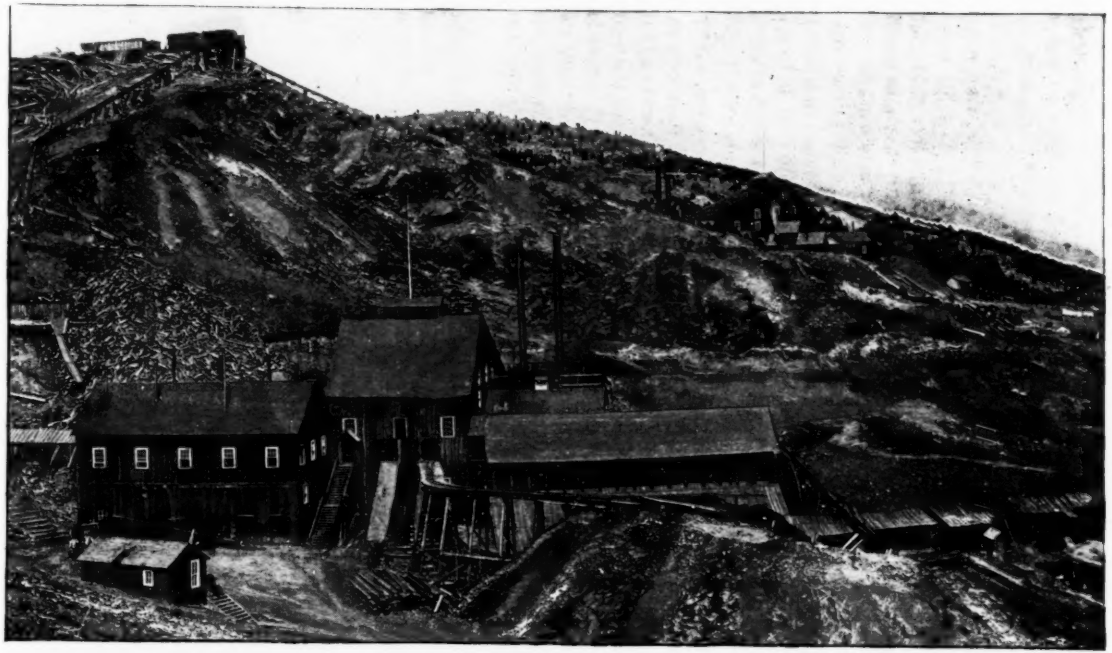
In 1873 the discovery of placer-gold called attention to the hidden treasures locked in the Hills, but it was not until 1874 that they were explored to an important extent, and not until 1876 that they were fairly open to settlement. The last Federal census shows that in sixteen years the population has increased from nothing, practically, to over 50,000 souls. In the census year the products of the mines of this region, according to a Census Bulletin, amounted to $3,376,656, of which $3,305,843 represented gold and $70,813 silver. But this indicates only a portion of the varied wealth of the region, for besides gold and silver, according to an

SOME HOMESTAKE MINES AND MILLS.

official enumeration, the Black Hills contain antimony, asbestos, barytes, brick- and fire-clay, building-stone, cement, coal, copper, glass-sand, granite, graphite, grindstone, grits, gypsum, iron, iridium, lead, lime, limestone, manganese, marble, mica, nickel, ocher, petroleum, pyrites, roofing-slate, salt, stucco, tin, talc, zinc, etc.

The commencement of gold-mining in the Black Hills was in 1873, when attention was confined exclusively to placer-gold. Since that time claim after claim has been located until they now number thousands, and several hundred are being actively worked. The placer mines having been about exhausted, the claims now worked are what are known as "lode claims"; that is, claims in which the gold is found in veins of ore-bearing rock. The first lode mine that was opened on a large scale in the Hills, and which alone has made that country famous in mining circles, was the Homestake. This mine at present employs an enormous force of men, working night and day "shifts," year in and year out, and pays out over $100,000 a month for labor alone. Titus E. Corkhill, of Lead City, State Mine Inspector of South Dakota, is authority for the statement that the average monthly output and clean up of this mine last year was from $400,000 to $500,000. It has been officially estimated that the total output of the Black Hills has amounted in value to $40,341,028, including $39,423,776 worth of gold and $917,262 worth of silver.

The ore in the Homestake mines is what is known as free-milling ore, but of a low grade. The method by which the ore is mined and handled is what makes the Homestake Mining Company such a remarkable success. They take advantage of nature's laws, particularly the law of gravitation, and do all the work, so far as practicable, by means of machinery, avoiding the expense and delay attending numerous handlings of material. For example, the fire-wood and lumber used in the various engine-rooms and mine-shafts is hauled by the narrow-gage Black Hills and Fort Pierre Railroad to a point from 300 to 500 feet above the place where it is to be used, and from here, by means of what are known as "wood chutes" and the force of gravitation, it is transferred to the desired point without other handling than simply throwing it from the cars. The same method is extended to the handling of ore. Cars are filled with ore by means of chutes from floors or levels above; and when a car is once filled with ore, no matter from what "level" it may be taken, the ore is ever after handled by machinery, being transferred to the various stamp-mills and crushed through the



WOOD CHUTES. STAR HOISTING WORKS. "OLD ABE" SHAFT.

agency of steam or water. The pulverized ore is allowed to flow in a stream of water over copper plates thickly covered with mercury. The gold is caught and held by the mercury, while the waste dirt is carried off by the stream in its precipitous descent down the mountain side. Twice each month they have what is termed a "clean-up," when the amalgam is taken from the copper plates, retorted and the gold is melted and molded into "bricks" and shipped to the "bullion office" or to the mint for coinage.

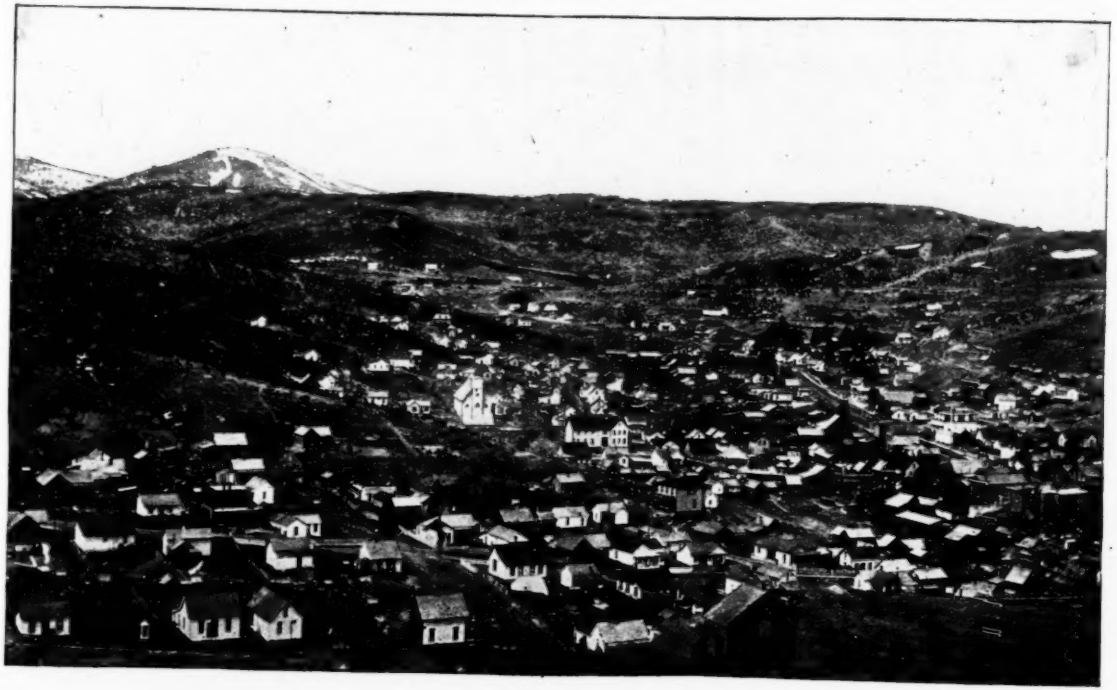
But it is the method of mining the ore with which this article has to do, particularly. In every mining district the method of work depends almost entirely upon the formation of the ground and the position in which the ore or mineral is found. Thus in districts where the ore veins are steep, narrow and quite rich, a shaft is sunk and then the ore vein is followed up, the "workings" being timbered by logs called "stringers," reaching from wall to wall. These walls are the boundaries of the vein on either side, and are known as the "foot wall" and the "hanging wall" of the ore ledge. As the "working" advances, planks (called in miner's parlance, "lagging") are laid on these logs, forming long boxes called chutes, for carrying the ore, as it is mined or "broken," to the lower floor. Here cars transfer the ore to the shaft, and it is taken thence to the surface. In cases where the vein or lode is broad, or lies horizontally instead of standing vertical, as is many times the case in the Black Hills, and a large amount of ground is required to be worked over, the excavation made is called a "stope," and another system of timbering adopted, called "stope timbering." In such mines the great problem with mining men is how to substitute for the worked-out ground some safe and sure means for holding up the top and sides of the "stope," and furnishing a solidity to the ground that can be depended upon.

In anthracite-coal mining an enormous pillar of coal is left standing at regular distances throughout the chamber. These pillars take the greater part of the weight of the ground which is overhead. Little or no attention is paid to the sides, they being hard and compact enough to stand without other support. But in cases of loose formations, or uncertain ground, as in the Black Hills country, it becomes necessary to use artificial means of support, *i. e.*, timbering both for the ground overhead and the side walls. The style of timbering used in the Black Hills is at once the simplest and the most efficient substitute that can be used to hold up the thousands of tons of rock. A "set of timbers" consists first of a

WOOD CHUTES AND HOISTING WORKS AT THE HIGHLAND MINE.

log eight feet long with a tenon on each end, 6 x 6 x 6 inches, called the post. Then comes the cap, consisting of a log 5½ feet in length, and with a tenon 12 x 12 x 6 inches. Then comes the tie, which is like the cap in all respects except that its tenon is 12 inches long by 6 inches wide. After the post is put in position another post is selected near it, and pieces of heavy iron, hasp-shaped and square at the top, are driven into these two posts and pieces of heavy plank are passed through the openings of these irons, which are called "dogs"; and with the aid of a similar brace constructed with the next two adjacent posts a platform is made by means of which the "timber-gang," consisting of three men, can attach the cap and tie. After the set is placed in position a "brace," consisting of a smaller piece of timber, is placed against the joint of the post and cap, or post and tie. Without this brace all strain put upon the timbers would tend to throw them out of place, and the timbering in a stope would be useless unless it insured solidity and compactness. Great care is required in cutting the timbers and making tenons, and for this reason it is all done by machinery. Should the timbers be so cut that they fit poorly, there comes the inevitable "swinging of the timbers" which results finally in the set failing to do its work, and unless the ground above is very firm, hard and compact, the stope caves in. As the work of mining progresses these sets of timbers are placed one upon another until quite a chamber is formed. An example of this is found in the enormous stope in the Highland mine, at Lead City. It is known as stope No. 5, on the fourth level, and is over 170 feet high, consisting of seventeen sets of these timbers, superimposed one on another.

A "timber gang" consists of three men who work together, handling logs which weigh many hundred pounds. A gang of good men, trained to work together, can put up about eight sets of timbers in a "shift" of ten hours. In the soft ground of the Black Hills every foot of the way requires timbering. First the shaft is lined with square sets of timbers, which are afterwards boarded on the side next to the earth, in order to prevent small particles of rock and dirt from falling into the shaft. Then when the tunnel is driven towards the ore vein, timbers called "tunnel sets" are put up. These consist of two posts and a cap, the posts being placed on either side of the tunnel, while the cap, which has mortises cut in either end to fit the tenon on the posts, is placed on top. Above the caps are laid two-inch planks, and still above these,

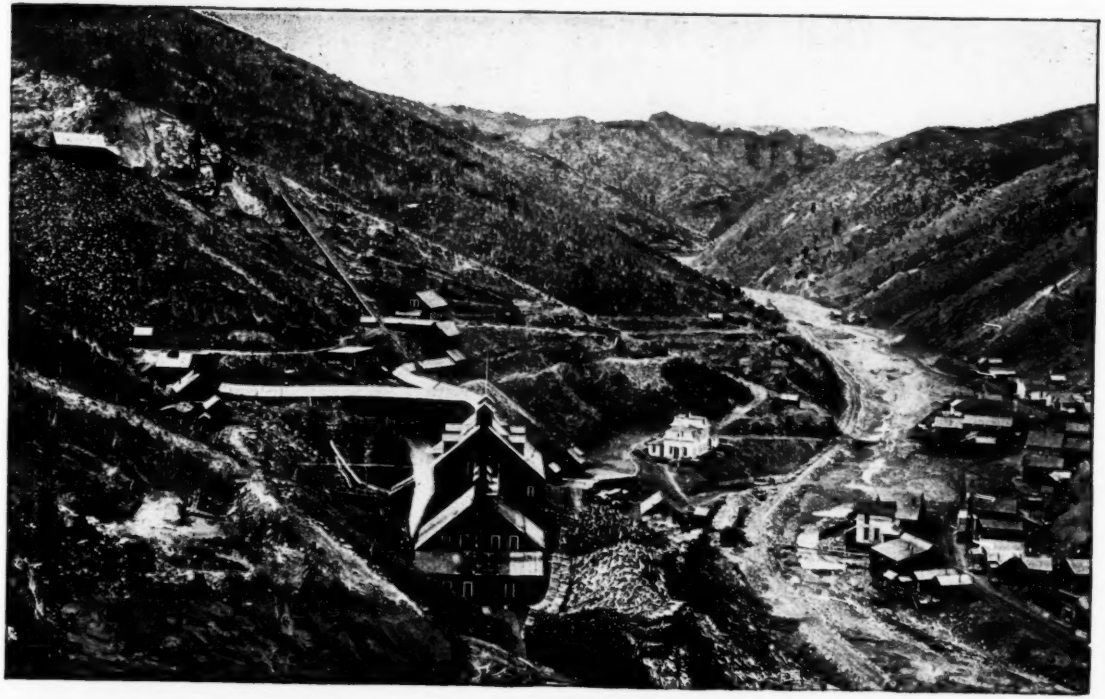


A VIEW OF LEAD CITY, INCLUDING RESIDENCE PORTION.

wedging the caps firmly to the posts, are blocks jammed in between the planks and the top of the tunnel. At the entrance to the level where the shaft ascends, is a large chamber called a "station," in which is placed a "station set," similar to the tunnel set of timbers, only much larger.

After sinking the shaft, and while driving the tunnel towards the ore vein, every foot of ground is prospected or assayed. The assayer determines the value of the ore either by fire or by wet assays. This of course takes considerable time, and for that reason in free-milling ores a resort is had to "panning," which work belongs to the "sampler." With a number of sacks and a small hand-pick he takes an average of the ground broken. Filling his sacks he goes to the surface and, after breaking the rock into many small particles, crushes it to powder in a mortar with a pestle. The powder is then placed in a large pan not unlike a shallow dish-pan, where it is mixed with water and by repeated washings over a tub with water in it, the lighter rock is gotten rid of. Continuing this washing, at the same time shaking well the contents of the pan, he rids the pan of all but the heavier particles of rock. In what is left he looks for the gold. Should he find any "color," as the presence of gold is called, he reports it, and the rock is hoisted as ore.

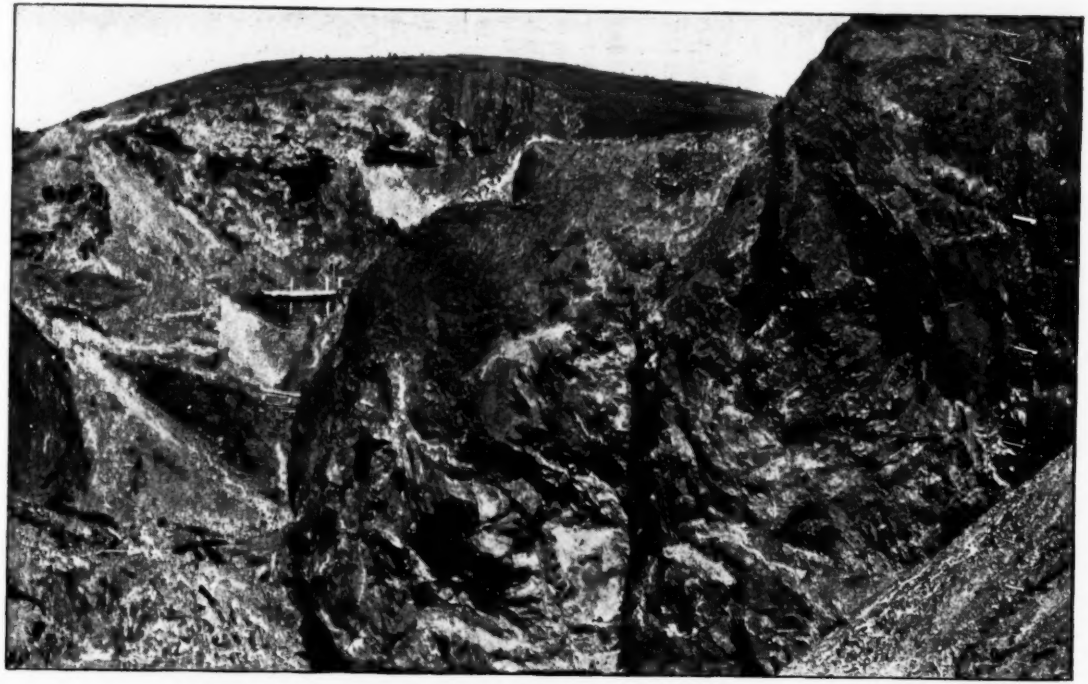
The "miner," as recognized in the Black Hills and in most mining districts, does not include the man who shovels the ore into the car, nor the man who drives the mule attached to the car, nor even the timber-men; he is above all these. He is supposed to be a man of wide experience and must possess great strength and endurance, and undaunted courage. His duties may require him to work under tons of rock that are ready to fall and crush him. In going to work he stands on the edge of an iron bucket clinging to a rope while he is lowered to his destination, if the mine is a small one, or drops 400 feet in half a minute, crowded with eight other persons on a platform five feet square, if the mine is a large one. Arriving on the level where he is to work he secures the tools—picks, drills and hammers—and proceeds to the spot where work has been allotted him. If he works alone, with a short drill and a three-pound hammer, he "puts in a hole." If he has the good fortune to be assigned a partner in his work, the partner "twists" the drill while he hits it blow after blow with an eight-pound hammer. To the uninitiated it is wonderful what skill these miners acquire with the heavy or double hammer.



FATHER DE SMET MINE. GOLDEN GATE. CENTRAL CITY.

Grasping the handle, about three feet long, with one hand on the end and the other placed about a foot above it, the miner with great rapidity and precision strikes the drill on the head. With each blow he hits the drill he emits a hissing noise from his lips, both to warn his "pard" that the hammer is coming, and as a vent to his concentrated energies. With equally good time and precision—for if he did not a broken fore-arm would be the consequence—his "pard" brings out the drill about an inch and turns it a little. This last is termed "twisting the drill," and is not as easy as it would seem. It requires some nerve to stand there and let a big hammer whiz by your ear, remembering at the same time that if you do not keep time in "twisting" something will happen. The danger is heightened by the fact that the head of the drill is only about an inch broad, and the only light a couple of tallow candles. But the men at the hammer are always more or less expert, and few bad accidents occur. Occasionally, at a sign from the "twister," the miner desists long enough to allow the twister to clean the hole. He then changes places with his "pard," and the work proceeds.

This routine is kept up until a sufficient depth is attained, when the hole is carefully cleaned and everything made ready for "loading." Dynamite is the explosive most frequently used in underground mining. It is nitroglycerin held by an absorbent, which forms a highly explosive compound that can be readily handled. The proportion of nitroglycerin used in most mines is 40 per cent. The explosive is made into "sticks," of which from one to four are used in a hole of four or five feet in depth. All the sticks to be used are carefully cut open with a knife and gently forced to the bottom of the hole with a piece of wood. Then is added the fuse, having at the end which goes into the hole a cap very much like the old style of percussion-caps used on muzzle-loading muskets. In this cap is a small quantity of fulminate of mercury, a chemical that insures the explosion of the dynamite. The fuse and cap being inserted in the cartridge, dirt is thrown into the hole and tamped down with a stick. The miner and his "pard" then move their tools from the immediate vicinity, and after examining the braces nearest the hole to ascertain that everything is all right, they warn any others who may be in that part of the mine by crying: "Fire one hole on the sill floor"—or wherever it may be—light the fuse and retreat to a safe distance. The explosion soon follows and as soon as the smoke has cleared away the miner and his "pard" gather up their tools and proceed to their next assign-



OPEN CUT OF DEADWOOD-TERRY MINE, BLACK HILLS.

ment. Before entering a place where "a hole has gone off" the miner carefully examines the ground overhead and around him to see whether the place is safe enough to work in. Having tested the ground they "bar" down and pick the loose pieces; this done, the work in that portion of the mine is finished. Then follows the shoveler, who fills the cars with ore or waste, as the case may be.

The great thing in the Black Hills mines, as indeed in all mines, is economy of work as well as expense. By making use of nature's laws, particularly that of gravity, great outlays are saved. A better illustration of this idea cannot be found than is furnished in the method of construction of a "raise" or "winze," which is a small opening connecting two levels. This "raise" is started at the roof of the lower working and, in miner's parlance, "driven" up towards the level above, inclined at an angle of 75°. The miner or miners having the construction in charge drill deep holes, and after loading them with dynamite, as before described, crawl out of the "winze" and retreat to a point of safety. When the "hole" is "fired" the loosened rock falls down the "winze," impelled by the force of gravity, thus doing away with the need and delay of shoveling that would have been necessitated by beginning at the other end of the "winze," and sinking it shaft-wise. Then every pound of rock would have to be hoisted out with a windlass, which would create heavy expense, to say nothing of the extra men that would have to be put into the bottom to shovel the ore into buckets, and the delay incident to the whole proceeding.

The same principle is applied in the mining of the ore wherever practicable. Where the claim is located on a hillside, with sufficient pitch, a tunnel is "driven" into the vein and work pushed forward until a good idea of the nature of the ground is obtained, then a shaft is sunk at a distance from the body of the ore, and at every hundred feet levels are driven into the ore vein. At the first level worked, generally the 100-foot level, the vein is all "stoped" out, and the ground above being but a slight crust, preparations are made and it is allowed to cave in; when this happens it gives them what is known as an "open cut," in which the men work on the sides or walls and blast and "bar" down the ore, which is conveyed by means of chutes into cars and thence to the mill without other handling. In this the great economy consists in the fact that no timbering is required and but very little shoveling, and aided by gravity the men in the open cut "break" or mine much more rock than they can when working in a "stope."

ROAD TO BALD MOUNTAIN, RUBY BASIN, BLACK HILLS.

# PRACTICAL HINTS ON HOUSE-HEATING.

*By Leicester Allen, A. B., M. E.*

## III.—THE HEATING EXPERT.

THE designer of a heating apparatus for a building stands in the same relation to the owner as the architect, with the difference that, as the architect has only himself and the owner to please, the expert who draws the plans and specifications for the heating plant has himself, the architect and the owner to satisfy. I might add that he has also to satisfy the contractor, since the latter will be asked usually to guarantee the work and will decline to estimate on it unless the drawings, plans and specifications are such that they plainly make it safe to give the required guarantee. This consideration fitly introduces the discussion of the phases that are assumed in the business of designing heating installations.

By far the more frequent of these phases is that in which the contractor is himself the designer of the apparatus; that is to say, he either makes the design personally, or has it made under his supervision, by some one in his employ. A second phase is that wherein the heating expert draws plans and specifications, either employed by the owner or by the architect, these plans being furnished to contractors for making estimates. A third phase is that in which a contractor desiring to enter into competition on some large and important job out of the common run of his business, employs a special expert to make plans, draw specifications, and make the estimate. Each of these phases of the business has its individual peculiarities.

The contractor in making his own plans will be apt to seek in all possible ways to cheapen the work to the last degree it will bear and yet operate sufficiently well to meet the guarantee he will be required to give, enable him to obtain the architect's certificate and get his pay. Rarely, if ever, is the best work put in in this manner. The best contractors will, of course, avoid doing disgraceful work; but between work actually disreputable and that of high excellence there may be a very wide margin. On the other hand there are petty heating contractors all over the country who will be satisfied with a shamefully disreputable job, if only they can contrive to get the work accepted and get pay for it. It is much

to be regretted that this class of contractors find employment in domestic heating work, as well as the heating work in rural school-houses and small churches. The prevailing ignorance as to what constitutes good heating and ventilation enables them to go on prosperously like quacks in other professions. But quackery is not confined to small contractors, as recent developments regarding the infamously defective ventilation in the public-school buildings of New York city has proved.

Upon no other subject connected with sanitary science has it seemed a task so Herculean as to diffuse information among the masses about ventilation. The effects of want of good ventilation are so subtile in their character, certain retribution for sins in this regard is so slow in coming, and when it comes is to uninformed people so seemingly unconnected with the sins, that it is almost impossible to bring such people to see the relation between cause and effect. At most, only a languid assent can be extorted from their minds to the proposition that good ventilation is essential to perfect health; and when they are told by some petty heating contractor, possibly as ignorant as themselves, that the ventilation in a building is good, they accept the statement without question, unless the facts to the contrary are so plain as to be detected by that most unreliable of organs, the human olfactory apparatus.

In either of the other two phases of the business, good work may be expected, although when the special expert is called upon to make a plan, specification and estimate for a contractor on some important job, he will often require all his firmness to hold up under the pressure for cheapness that will be brought to bear upon him.

The most satisfactory of all ways in which to get designs for heating and ventilating apparatus is for the owner or architect to employ the expert under instructions that, while needless expenditure is deprecated, nothing the usefulness of which can be demonstrated, no feature for the introduction of which intelligent and satisfactory reasons can be assigned, is to be omitted. To get a good job, the cost must not control, but must depend upon what is needful. A *good job* must be the first aim; to get this as cheaply as possible the subordinate end. Probably as good an example of a well-designed heating and ventilating apparatus as this country affords is that designed for and erected in the Metropolitan Opera-House, New York. Here the best results were reached—and only could have been reached—by putting cost into the background.

Especially true is this as applied to the numerous tall office-buildings which characterize the present era in the large cities of this country. I have never been in one of them which could be called decently heated, and as to ventilation it would appear that this is entirely disregarded. If fresh air is wanted, it is only to be obtained through opened windows, in the strongest possible drafts and at the risk of scattering or disarranging valuable papers. So far the application of hot water to the heating of such buildings has seemed impracticable, and steam appears to be the sole reliance. The apparatus is designed to be powerful enough to supply heat for the coldest weather, and consequently overheats in mild weather; and as most people will endure a close, stifling apartment in preference to a chilly one, overheated offices in tall buildings are the rule. Were there no other criticism to be made against tall buildings than the impracticability, without undue cost, of supplying them with good heating and ventilating apparatus, this would in my opinion be sufficient to condemn them. If they are to remain a feature of modern life in cities some one ought at once to grapple with the problem of furnishing them with warmth and air in accordance with established sanitary principles. To get into a semi-perspiration, and to relieve the oppression of heat through the admission of a cold-air draft through a window of one of these buildings, is about as sure a method of laying a foundation for lung diseases as could be contrived, had this been the special purpose of a tall office-building.

In designing an apparatus independently of any consideration for the contractors who will be invited subsequently to estimate upon the work, too much care cannot be taken to avoid any ambiguity in the drawings or the specifications. Not only the capacity of the boiler required, but the *kind*, should be named—one of a kind best adapted to the character of the job to be put in. There are many things besides the mere capacity that may influence a selection. The head-room in the cellar may be scanty, and a boiler that can be conveniently erected in the space obtainable may compel a preference for one rather than another that might otherwise be chosen. The building may be one which, having been heated for many years by a hot-air furnace, is now required to be heated by steam. To avoid cutting through walls for the purpose of getting a boiler in the cellar, a boiler of the sectional type may be chosen; but whatever boiler may be decided upon, the decision ought to be final with the expert who draws the plans and

the specifications, and positively and plainly specified. The same remark applies to radiators, to valves and hot-air registers; in short to all the manufactured articles which contractors usually purchase from the manufacturers as part of the materials for the erection of heating apparatus. The exact way in which registers or radiators (if the latter are of the direct variety) are to be finished should be stated in the specifications, and the provision required for protection from fire where pipes pass near to or through floors or wood-work should be very carefully and accurately described. The covering of pipes in the cellar should not be merely stated as a general requirement, but the precise kind of material, or materials, if more than one is to be used, as well as the thickness, manner in which the materials are to be applied, and the means of securing them in place, should be named. The most fruitful source of difficulty and disagreement between architects and contractors is ambiguous or defective specifications. Most specifications are not sufficiently specific with reference to details. The erection of heating apparatus is a business comprising a multiplicity of details; if any are omitted or not sufficiently described, the seeds of misunderstanding and consequent friction between the architect and the contractor will be needlessly allowed to exist and in such a case the expert becomes a target for the reproach of both.

The plans should indicate definitely the position in which all radiators or registers are to be placed; the shape of the radiators, their heights and sizes of radiator connections, as they are technically called (being the pipes for supplying and draining radiators), should be plainly marked on the plans. These should also plainly and unmistakably indicate the location of every pipe to be used in the apparatus, the sizes, the reduction of sizes in different pipe-runs, the position and sizes of reliefs, and all other details more easily shown on the plans than described in the specifications, or which if so described are more clearly understood by the aid of plans.

The setting of the boiler should not depend upon a mere general requirement that it shall be done in a "good, workmanlike manner." That which will be claimed by contractors to be good and workmanlike, will, if left to them to specify, not often satisfy an expert. It is essential to the proper working and durability of a steam or hot-water apparatus that the boiler or hot-water heater should stand on a firm and solid foundation that will not settle. The ash-pit, moreover, should always be paved with hard brick set on edge,

laid in good mortar. This gives a smooth bottom from which the ashes are easily removed, and it will last as long as the apparatus. The mere grouting over of the ground to form a hard bottom for an ash-pit should never be permitted. If the boiler be of the portable variety, of which there are now a number of good ones in market, it ought to be covered on the outside with some non-conducting material the same as steam-pipes are covered and for the same purpose, to avoid over-heating the cellar at the expense of other parts of the building. If the boiler is to be brick set, the thickness of the masonry, and the manner of mounting the boiler should be explicitly stated in all particulars. It is no uncommon thing, when this is not properly provided for, to find masonry giving away under the influence of expansion or from other causes within two or three years from the time of its erection, whereas it ought to last as long as the boiler.

The sagging of pipes through insufficient support often causes a heating apparatus to work ill that has previously operated in a satisfactory manner. Hence the method and appliances for supporting the pipes should by no means be left to the judgment of the contractor. But frequently in these days of speculative skin-building, the sagging of pipes is due to the settling of floors, and is not chargeable to faults in the plans and specifications, or to the neglect of the contractor. In the building wherein I am now writing there is scarcely a steam-pipe that is in the original position as left by the contractor and accepted by the architect as satisfactory. No one of the floors is level, and some of them have so sprung that many of the radiators can with difficulty discharge the condensed water. When steam is first turned on the system the water hammering in the pipes is to the last degree annoying, and at no time of the day are the pipes everywhere noiseless. I do not know whether the job was properly put in at first, never having inspected the work in the cellar, but no matter how well, the settling of the building and distortion of the floors would have been sure to let the pipes sag so as to form water-taps and obstruct the free flow of the steam. It should be known to users of low-pressure steam apparatus that the settling of a steam-pipe to an amount equal to its diameter is enough in many cases to interrupt the flow of steam to a radiator which the pipe supplies. The coöperative plans and specifications purport to be a description of what the contractor will be required to supply and erect, and in nothing does the skill of the expert appear more conspicuously than in their completeness;

nothing will more accredit a planner of heating apparatus to an intelligent architect than neatly drawn, comprehensive plans, and thoroughly drawn, explicit specifications.

Indirect radiators are now used in one of two different ways, each of which has some advantages not possessed by the other. The designer will have to consider the merits of these methods. Such radiators placed in a cellar by putting them in boxes and hanging them on the floor beams as closely as possible to the registers connected with them work well generally, but an apparatus so erected renders a cellar nearly always useless for other purposes except storing coal, on account of the room taken up by the heaters and the pipe connections, and the temperature which the boiler, the pipes—even if well covered—and the radiators will maintain in the cellar space. The preservation of fruits, vegetables and other perishable substances in the cellar must, therefore, either be abandoned or a special cold-room must be provided. It is well-nigh impossible in most cases to so locate and inclose a cold-room that it will not interfere with running steam- or hot-water pipes, or the location of a radiator where it is required. There is this to be said, however, that, in a cellar containing steam- or hot-water apparatus, if proper special provision be made for ventilating (a provision that ought always to be made, though for the most part omitted), the air can be maintained dry and in good sanitary condition, provided that the cellar has a good cement bottom or brick pavement, and that the walls are so built as to exclude entirely any inflow of exterior surface water during wet weather. A good clean and wholesome playroom for children in bad weather can thus be supplied—I assume that the boiler and coal-room are closely partitioned off from the rest of the cellar, as they always ought to be—except for the fact that it will nearly always be too warm for the comfort and health of children in active exercise.

This evil is thoroughly obviated by another system of indirect radiation that has of late years been much employed by a leading steam-heating firm, and the advantages of which are so plain to the expert that it ought to be used more generally. This method consists in placing the boiler and the indirect radiators all together, in a brick inclosure, and conducting cold fresh air from the outside into the lower part of the interior. Here, passing up over the heated surfaces of the boiler and the radiators, the air is warmed and is conducted by tin-pipes either to registers set in the floor or to the bottoms of tin wall-flues which conduct the heated air to the different parts of the

building. It has been objected to this system that it is difficult to obtain and maintain a uniform delivery of warmed air through the different pipes and flues; a difficulty which, doubtless, exists in some examples of apparatus erected upon this plan. It is certain that much skill is necessary in so arranging the plant as to secure uniformly good delivery from all the registers, and it may be necessary—I think it would always be wise—to provide cold-air boxes leading from different sides of the building to obviate the sometimes adverse influence of winds blowing from different quarters. With such provision and careful proportioning of the air-pipe areas with reference to their lengths and the number of elbows required in them, good circulation can be secured, and in my opinion no better system of heating and ventilation by steam or by hot water has yet been produced than this. If the brick work be lined with sheet tin the masonry may be light and thin, without danger of admixture of cellar air and dust with that inducted from the exterior of the building. The system has, moreover, the advantage of cheapness as compared with the one described in the preceding paragraph.

For schools and churches, where a fan-blower is employed to introduce fresh air, the system is admirable, and it can be erected in such a compact space that much room can be economized for other purposes. It can be placed on the floor of a basement, as well as in a cellar, and with careful designing can be so arranged that nearly all the air-pipes leading to the flues can be concealed.

In conclusion, let me say that nothing but careful study in the application of natural principles and thorough knowledge of these principles, coupled with the determination to adopt and hold to that which his judgment tells him is right and good, can insure success to a heating expert.

# EVOLUTION OF THE CONSTRUCTIVE FACULTY.

*By John M. Burnett, C. E.*

AMONG the first and apparently the most instinctive of all the faculties exercised by sentient beings is unquestionably the constructive faculty. We are taught this by observation among even the lower animals. The birds are great builders, the African ant has long been a study for naturalists who like to trace a resemblance between the lower orders of being and the self-asserted masterpiece of the Creator, and the accomplishments of the beaver have been regarded as little less than wonderful.

The constructive instincts of the last named creature, indeed, seem to place him side by side with human beings in the possession of the faculties of reason. Having determined to become the founder of a family he selects the stream that he wishes to improve in accordance with his semi-aquatic needs, and then undertakes a careful survey of its shores to learn the most eligible site for his proposed new Beavertown. It is to be presumed that all the sinuosities of the stream are carefully noted ; that the force of the current is observed ; that soundings are taken to know if the channel is navigable for logs, and that the most suitable place for a dam is thus selected. Then comes the quest for material. The little engineer searches the forest for suitable trees, and displays his discrimination as a scientific naturalist by selecting willow, birch, and other light wood easily worked by the tools at his command. We are told, too, that he makes use of drift wood in his operations ; but we would suspect that he turns any force in nature that he finds working in his behalf to account when we observe the astuteness that always leads him to go up stream and never down stream for his supplies, and that enables him to know all the economy of water transportation. But however this may be, we know that he obtains his logs, and that, after moving them by water carriage to the point where the dam is to be constructed and cutting them to the proper length, he arranges them in place, convex to the current if the force is considerable or straight if it is sluggish, and then with stones and soft earth closes all avenues of escape for the water until his reservoir is completed.

Thus far the beaver works exclusively in imitation of the engineer; but having completed his dam he is ready to become an architect and build his town. At this work his wonderful constructive accomplishments will be again observed. It was an old notion that he divided his dwelling into separate apartments, and this seemed to indicate a development of the social or domestic instincts that was quite remarkable. Closer observation, however, while rather exploding this notion, has added to the testimony in favor of his ability in construction. What were thought to be partitions are found to be posts erected to sustain the roof. It takes a long time for savages of the human species, whose beginnings in construction are supposed to be directed by reason, to conceive anything half so inventive as this expedient.

Certain architects with æsthetic notions will be likely to sniff at the idea that the beaver can be an architect in the true sense, or hold any relations with the architectural profession. But it is not so certain that they will be right. There is a good deal of architecture beneath the conceptions of a beaver, and there is other architecture that would be structurally better had the beaver been more carefully consulted in the plans.

In truth the constructive faculty is at once instinctive and logical in both man and beast; and it would be hard to tell at what period of life it is developed in the human species. Watch little children at play. You will observe that their earliest efforts are directed towards some form of construction. If you give them alphabetical blocks they will not begin their use at once by trying to distinguish one block from another. They will begin by piling the one upon the other in some form of structural combination. The combinations will be unmeaning perhaps in the first essays, but the little architects will be ready to combine them in the form of a house at the first hint that the blocks can be arranged in this form. Again, let them play by the brook-side, and you will soon find them building dams of mud, or training the water to run in new canals or channels. The alphabet they will study only after repeated efforts at tuition; but they will have launched whole navies of marine structures, improvised from chips, before they learn to spell either block or brook. It is doubtful, indeed, if they would ever learn to spell did they not find that even spelling is a form of structural combination that can be utilized for the gratification of their fundamental instinct for building.

Constructivenes is the first developed of all the human facul-

ties, and it is also the most enduring and the most persistent. Architects complain that their employers are constantly interfering with their plans. But their employers cannot help it. Having a work of construction to be executed they are drawn by an impulse as irresistible as the current of Niagara to direct the architect as far as possible along the line of their own conceptions; and the sensible architect, confessing his subjection, will try to give architectural features to plans which he may only in part have conceived. To say truth, he might not always have conceived so well had he been left entirely to his own devices. There is not a painter on earth who is not sometimes obliged to confess that the structural instincts of the unlearned may occasionally shame his learning; and as to the engineer, he is generally a man of details executing the conceptions of men who are not accounted structural experts.

Will this be thought derogatory to the profession of the engineer? It will not be thought so by any sensible engineer when he considers the universality of the engineering faculty. Comparatively few of the great works of the world, using the word great in this case as a synonym for useful, were conceived by professional engineers. The projector of the Erie canal was De Witt Clinton, merely a governor. The projector of the Suez canal was De Lesseps, a French count who may have found a course in surveying sandwiched into his school curriculum, but who was certainly not a trained engineer. Not many years ago all the civil engineers of New York were at their wits' end to devise a scheme of rapid transit that would stay the tide of population which threatened to fill up the waste places of Long Island and New Jersey at the expense of Manhattan Island. Railways were projected over the house-tops, under the cellars, under the streets, through the middle of blocks, and in every location where a railway was thought engineeringly conceivable. These plans were all doubtless highly scientific; but as it was not felt that they could be commercially successful they failed of receiving the necessary kind of approval. Finally a bone-setting doctor quietly went to work and solved the problem that was bewitching all the civil engineers by causing the construction of the elevated railways. Dr. Gilbert did not construct these railways without the aid of the professional engineer. This is not the assumption. He only evolved from his structural consciousness a plan of rapid transit, certain to prove more popular than any other plan that will ever be executed, which he turned over to the engineer to be realized in brick and iron.

This is the common experience. When the Medicean wanted to get back to Florence after his expulsion he found the way blockaded by some works of military engineering that long proved too formidable for his resources. But they were not executed in accordance with the plans of the military engineer. They were executed after the plans of one Michael Angelo, sculptor, painter and architect, the same Angelo who was afterward kept so diligently at work road-making by the Pope that the labor interfered seriously with the execution of his pictures and statues. And what of Leonardo da Vinci? Here was another painter who might have contributed to art many great pictures that were never painted simply because engineering faculties were so strongly set in his mental composition that he was almost forced into their exercise both at home and abroad. It may be said that these examples are drawn from a period when professional pursuits were less specialized than they are to-day. But, except for details, the engineering profession is never specialized. Most of the great works of this country, all recently constructed, were projected by men who were not professional engineers. Jay Gould, I believe, got as far as trundling a wheelbarrow at map-making before he began to build and buy railroads. But though he has built many railways since, he is no civil engineer. He is only a financial engineer.

The writer would like to make, also, another point. He is reading with a great deal of interest those admirable articles, now appearing in THE ENGINEERING MAGAZINE, on the water-front of New York, by William Nelson Black, and he must say that in all their bearings, political, scientific and constructive, they are among the most instructive engineering articles ever printed. Yet he is told that Mr. Black is not a civil engineer. He is only one of those constructive painters, one of the kind that can never keep their hands off engineering problems when they think that anything is going flagrantly wrong. If this be true, it certainly helps to prove the truth of all that has been said on the preceding pages; and the civil engineers of New York can only atone for their past inertia by indicating their appreciation of good engineering suggestions. They should rise in open rebellion, and help Mr. Black to send all the drift-wood now floating around the piers of New York to the final crematory of everything evil.

In reflecting on the number of great engineering works that have been projected by laymen the suggestion that first comes to mind may not seem quite flattering to the engineer. Can it be true

that a technical training is calculated to keep the attention fixed only on structural details, and to weaken those powers of comprehensive generalization from which great conceptions spring? This is the question that one is at first inclined to ask; and there are not wanting examples in other professions than engineering that seem to warrant an affirmative answer. We know, for example, that many lawyers who stand very high in their practice at the bar are yet exceedingly poor judges of constitutional law. Our legislative bodies are composed very largely of lawyers. Yet no session passes without the return of bills from the executive on the ground of unconstitutionality, and the objection is generally sustained. When these bills were under consideration, however, no hint of unconstitutionality ever came from lips that might be supposed to never open without the utterance of such wise phrases as "organic law," "fundamental truths," or "constituent principles."

But this example is by no means conclusive. It is certainly not the excess of technical training, nor even the habit of special pleading, that contracts the horizon of the lawyer. It is the lack of a technical training of the broader kind. The best judge of constitutional questions among men with equal faculties of ratiocination will be the men most conversant with history; and lawyers are apt to be weak on constitutional law simply because their general education has been neglected. A man not thoroughly trained in history, and not familiar with the constitutional principles of all countries that limit the exercise of authority, cannot be a good constitutional lawyer no matter how much he may know about marriage and divorce, contracts, criminal procedure, seizure and possession, and such like accomplishments. But as it is with the lawyer so also must it be with the engineer. It is not his technical training that prevents his becoming an originator. It is in part a careless habit of not sufficiently regarding the fundamental objects of his art. His technical training should give him great advantages as a projector, and it doubtless does give him great advantages in the projection of works, which, like the Eads jetties, for example, require inventive skill even in the conception; but it will not teach him what it is desirable to undertake. This is a knowledge that springs from the intuitions of men, and the amateur is as likely to have large intuitive faculties as the professor.

To confess the truth, it must be said that the engineer, compared with men in most other professions, is placed at a disadvantage. He is simply crowded from the position where he should

win his highest distinction by the omnipresence of the constructive faculty. There are only a very limited number of engineers in the world; but the men who plan engineering works pretty nearly equal in number the census returns of population. Nothing of the sort is true of the legal profession. There are plenty of litigants by instinct. But there are no lawyers by instinct; and it happens, therefore, that the lawyer is sometimes treated with a deference greater than his accomplishments warrant. The average lawyer is a man who knows the law after he has looked it up. His knowledge of court practice gives him advantages; but the layman may be just as alert as the lawyer in consulting the revised statutes, and, after running over Blackstone, almost as learned. Still, as he would not know how to navigate the tortuous channels of legal practice, he always thinks it necessary to take on a pilot. But this is not true of engineering. The structural instinct is so strong that most men who have planned an engineering work would almost think themselves equal to its execution. They would only call in the engineer to save their valuable time.

It must be said, however, that the engineer is often himself to blame for the facility with which he is pushed aside by the layman. Naturally enough, he is more likely to be captivated with an idea that is scientific than with one that is simply practical but without any marked scientific features; and as a consequence the consideration of economy works in behalf of his rival. An accomplished engineer would probably have been ashamed to project the elevated railways of New York. They involve nothing more in plan or construction than is involved in the simplest of iron bridges. But, down to date, they have proved to be the only conceptions that capitalists can appreciate, notwithstanding the promptings of men who are accomplished journalists, constructors, and financiers.

Finally we come to a conclusion and it is here. The constructive faculty is so nearly universal that the members of the engineering profession cannot expect to become the monopolists of good plans; but they can greatly enlarge their opportunities for exercise and ride more comfortably if they will learn to bridle and saddle their science, and teach it to amble gently over common roads. In the projection of a good work, if the plan be supplemented by a little tact at financial engineering, there may be fortune; but in the execution of the plans of other men there is only a contract or a salary. If only a contract or a salary, too, the money is sometimes very difficult of collection.

# ELECTRICITY.

*Conducted by Franklin L. Pope.*

IN his inaugural address before the American Institute of Electrical Engineers at Chicago, President F. J. Sprague, one of the best authorities on electric-railway engineering, stated that there would probably be in operation in this country within twelve months no fewer than five electric locomotives of from 700 to 1200 horse-power and from 45 to 80 tons weight. These machines, he said, would be capable of hauling trains of 450 tons at 30 miles per hour up a gradient of 26 feet per mile. They would also be capable of attaining high speeds, and would be operated at an electric potential nearly double that now used in ordinary street-railway practice. Mr. Sprague is of the opinion that in the case of a high-speed and long-distance service, such for example as that between cities situated like New York and Philadelphia, the best results will be attained by a frequent service of comparatively small trains, as for example, two-car trains running at ten-minute intervals. He estimates that two-thirds the quantity of copper now in use in the long-distance telephone service between New York and Boston will be ample to meet the necessary requirements of the conductors for such a service. Mr. Sprague regards the suburban service of the Illinois Central railway at Chicago as an almost ideal opportunity for the establishment of a system of electrical propulsion.

The problem of railway propulsion by electric motors is discussed in the *Railroad Gazette* by Arthur T. Woods. It is interesting to observe that while he looks at the subject from the steam-engineer's standpoint, his conclusions do not differ materially from those of Mr. Sprague, and other well-informed and conservative electrical engineers.

Another of the principal street-railway lines of New York city—the Second-avenue—has received permission from the Railroad Commissioners of the State to change its motive power from horses to electricity. It is announced that a storage-battery system is intended to be used.

The *Street Railway Gazette* is authority for the statement that out of the 400 street-railways now in operation in this country, more than half have definitely adopted electricity as their motive power. There is probably no instance in the history of transportation in which a change of such a radical and extensive—not to say expensive—character, has been effected in so short a time.

AN interesting example of electric-power transmission is that of the Gold King stamp-mill near Telluride, Col. A Pelton wheel, receiving water through a two-foot steel pipe under 320 feet head, drives the generator at a speed of 833 revolutions, giving 10,000 alternations per minute. The generator, by an automatic compensation, is made to maintain a constant pressure of 3000 volts at the motor, three miles distant. The line runs 2500 feet directly up the mountain from the power station, and thence passes over a rough, and in winter almost inaccessible, country, to the mill. The working motor, being of the synchronous type, requires a special device for starting it, and this is furnished by a small auxiliary motor of the Tesla type. The operation of starting is accomplished by one man in about two minutes. The economical efficiency of the synchronous motor system, exclusive of loss in conductors, is found to be 83.5 per cent. at full load and 74 per cent. at half load. The capacity of the motor is 50 horse-power. This is the first example in this country of the installation of a large alternating motor, but the results already attained indicate that the simplicity, flexibility and wide range of application of the alternating system, are likely to make it,

at least for large enterprises, the system of the future.

An alternating current power-plant is now under construction for a quartz-mill in Colorado which will have a generator of 750 horse-power and a motor of 250 horse-power located at a distance of ten miles. By making use of a pressure of 4000 volts at the generator, and allowing a loss in the line of 20 per cent., the cost of copper in a line of this length becomes only from 10 to 15 per cent. of the aggregate cost of the plant.

AN expert who has had occasion during the past year to inspect more than a hundred central lighting stations has given a report of his observations, showing a state of affairs which, to say the least, is not creditable to the commercial common sense of the owners of these establishments. Many of the plants are as badly located as possible with reference both to transportation facilities and to economy in electrical distribution; no consistent or intelligent plan of station construction seems to have been generally followed; while the diversity of arrangements of motive-power is most extraordinary. In many instances high-speed simple non-condensing engines were used, although the load was absolutely steady, and abundance of water for condensation might have been had for the taking. One characteristic example of amateur engineering mentioned is that of a plant located nine miles away from a village of 2000 inhabitants, in order to utilize a water-power which at best was only available part of the year, and which has since been practically destroyed. Another equally instructive example of how not to do it came under the observation of the writer a year or two since, in which the coal for an electric arc-light plant was being hauled in wagons to an elevation 1500 feet above the level of the railway station, but less than two miles distant, as the crow flies, although the plant might just as well have been placed alongside the railway, or better still, at an unused water-power near by. There would seem to be plenty of missionary work in sight to occupy the Institute of Electrical Engineers for a number of years to come.

THE system of electric lighting used on the Pullman "vestibule trains" making long runs consists of a Brotherhood 3-cylinder engine and Eickemeyer dynamo on one base, occupying an enclosed space of about 20 square feet in the front end of the baggage-car, and taking steam from the locomotive boiler through a flexible pipe. The main conductors are run in moldings over the roofs of the cars, and the connections between the cars are made with flexible multiple cables. Each car carries also 32 storage-cells as a reserve in case of accident or disconnection. In a 6-car train there are usually 98 16-candle-power and 78 8-candle-power incandescent lamps, and in the summer 7 fan motors are added. For the round trip of 1824 miles, from Jersey City to Chicago and back, about 3300 lamp-hours are required. The average cost of equipping such a train is given as $968 per car. The average cost of maintenance per lamp per day, including everything except cost of steam supplied from the boiler, is 7.17 cents. The batteries may be depended upon to maintain the lights for about four hours, when the dynamo is not at work.

REFERENCE has been made in these notes to the long-distance electrical transmission plant at Portland, Oregon. Some further particulars of interest respecting it have recently been given by C. F. Scott. Alternating dynamos, driven in pairs by Victor turbines of 300-horse-power each are employed, delivering current direct to the mains at a pressure of 4000 volts. These are of copper wire, 0.2 inch diameter, and are carried overhead on glass insulators thirteen miles to a sub-station in Portland, where the currents are received at a pressure of 3300 volts, reduced by transformers to 1100 volts, and then distributed through the city precisely as if derived directly from a dynamo. Seven generators are now running at the power station at Willamette falls, each supplying 1250 16-candle-power lights in Portland. The plant has been running nearly two

years, and its performance appears to have been in the highest degree satisfactory.

ONE of the curious legal complications to which the administration of the patent laws by the courts sometimes gives rise is exemplified in the history of the inventions of Sawyer and Man. These men applied for patents in 1878 for an incandescent lamp carbon of fibrous material, in an arched form, subsequently treated by heating in a carbonaceous atmosphere. They are asserted to have made and publicly exhibited a large number of such lamps, prior to Edison's work in the same direction, but for various reasons their work failed to achieve commercial success. Ultimately their rights passed into the hands of the Westinghouse Electric Co., together with another patent which had meantime been issued to Edward Weston, for the hydrocarbon process, as the result of a successful contest for priority made in the Patent Office in his behalf against Sawyer and Man. More than two years ago, a suit brought against the Edison interests on the arch-shaped fibrous carbon patent of Sawyer and Man was dismissed by Judge Bradley mainly on the ground that their invention had not been brought to a state of sufficient perfection to anticipate that of Edison. Quite recently another suit, brought against the Edison Company upon the Weston patent, has also been dismissed by Judge Acheson; this time on the ground that Sawyer and Man's carbon was a completed practical invention and had been in actual public use. The facts themselves, as well as the testimony in support of them were substantially the same in both cases, so far as the work of Sawyer and Man was concerned. If the views of Judge Acheson, rather than those of Judge Bradley, are sustained in the appellate court, the general opinion of the world as to whom is due the credit of the invention of the most essential element of the modern incandescent electric lamp will apparently have to undergo a material revision.

THE question as to the best course of study to be pursued by young men seeking to gain a thorough knowledge of electrical engineering received considerable attention at the late annual meeting of the Institute of Electrical Engineers. Most of the leading technical colleges were represented by their professors of electrical engineering and physics, and the proceedings, which were quite animated, served to contribute much valuable information on this important subject. In a paper read at this meeting Professor Owens pointed out that at the present day there were really three distinct classes of electrical engineers—installing engineers, who superintend the construction and operation of lighting and power plants; designing engineers, whose province relates to the construction or manufacture of machinery and apparatus, and a third class who are engaged more particularly in laboratory, standardizing and experimental work. He thought that the course in any technical school ought to recognize these distinctions, and that it should be so shaped as to conform to the different requirements of the specialized divisions of electrical engineering. While it is neither desirable nor possible that the courses in the different schools should be alike, it is obvious that much waste of effort might be avoided if the different institutions should observe a certain unity of purpose and treatment. All were agreed that the importance of mechanical drawing and of manual training as factors in elementary education could not be overestimated. "The practical engineer," said Professor Jackson, "must be preëminently an enthusiast, while he is at the same time a candid and careful thinker."

THERE are fourteen establishments in the United States engaged in refining copper by the electrolytic process, employing 36 dynamos, having a total capacity of 1814 kilowatts. A capital of more than $1,000,000 is invested in the business, and the annual output of refined copper, including that of works not yet completed, will amount to 43,800 tons. The plant of the Anaconda (Montana) Mining Co., when extensions now in progress are completed, will be the largest in the country, having a capacity of 10,800 tons per year.

The cost of installing an electrolytic plant having a capacity of 1,000,000 pounds per month is about $125,000, inclusive of buildings. The value of the material under treatment at any given time would amount to about $80,000 in addition. The crude material used is black or blister copper, containing 96 to 98 per cent. of metal, and the electrolyte is a solution of sulphate of copper. Theoretically, a current of 385 amperes will deposit one pound of metallic copper per hour. An experimental plant for extracting copper direct from the ore by electrolysis, is in operation near Berlin, Germany, which is believed to be successful, though little information has been made public respecting the results.

AMONG the various contrivances of later years tending to render life worth living during the heated term, the ubiquitous little electric fan-motor certainly holds no inconsiderable place. A few dollars expended for the plant, and one cent per hour more or less for the electric power to operate it, is surely not an extravagant outlay for the amount of solid comfort which one recives as a *quid pro quo*, as he toils at his desk during the breathless midsummer days. The latest improvement in this line is a motor which has an additional slow horizontal rotation upon its standard, whereby the breeze of the fan is impartially distributed to every part of the room.

THE results of a recent prolonged life and efficiency test of the incandescent lamps of ten different American makers, made at the electrical laboratory of the Ohio State University, showed that the mean candle-power of the lamps rated at 16 did not exceed 14.5; that the candle-power falls off with use approximately at the rate of 10 per cent. for each 200 hours; that the life of 96 out of 127 lamps exceeded 1100 hours, and that the average initial efficiency was 4.2; after 600 hours 5.6 and after 1200 hours 7 watts per candle-power. One of the most important results indicated by the tests was that the blackening of the lamp-bulbs after considerable use is in all probability largely due to vapor of mercury left in the lamp-chamber by the Sprengler pump, this evil being decidedly less apparent in certain makes of lamps which were claimed to have been exhausted by mechanical pumps. The tests indicate that if the consumer were permitted to select his own lamps without reference to their efficiency, it would be possible for him to obtain commercial lamps which would give from 400 to 500 hours service with a falling off in light not exceeding 12 per cent. The great difference in the results obtained from different makes of lamps suggests that a line of research of this kind might be made very profitable both to the central station manager and the consumer.

A PAPER read by Mr. Hugh Neilson before the Canadian Electrical Association makes some interesting comparisons between the long distance telephonic and the ordinary telegraphic service. Mr. Neilson's views are strongly confirmatory of the truth of certain observations of our own on the same topic in the May number of this magazine. He says that the long distance telephone rates in the United States are based on a schedule of one cent per mile, with a minimum charge of fifty cents. It appears that some complaint is made by the customers, that for distances over 200 miles these rates are too high, but Mr. Neilson points out that owing to the unavoidable differences of conditions, telephone rates, unlike telegraph rates, must be considered from the same standpoint as railway tariffs, that of distance traversed. To carry on a telephonic communication requires the exclusive use for the time of two wires, while by applying the quadruplex system of telegraphy, four simultaneous communications might be sent at once on each of these wires, so that all things considered, the earning power of a telegraph wire may be anywhere from two to eight or more times that of a telephone wire, computed on the basis of the number of words transmitted. Mr. Neilson therefore considers that the only necessary limit to the distance of telephonic transmission will prove to be a commercial one. He claims that Canada leads all other countries in the general

use of the telephone; and asserts that more telephones are there in use, in proportion to population, and at a lower average rental, than in any other country in the world.

THE question of the comparatively economy of steam locomotives and electric motors for suburban railway traffic has been much discussed of late. The editor of *Electric Power*, relating his observations and experiences in Colorado, recently mentioned having seen a heavy locomotive hauling a baggage-car and two coaches manned by an engineer, fireman, baggageman, conductor and brakeman, competing with an electric car on a parallel track which was carrying three times as much paying load at half the fare, and handled by a motorman and conductor. The indications are that this will soon become a frequent spectacle in many of the thickly settled districts of the country. The popularity of the electric system is due to the low fare, the greater frequency of trips, the facility for alighting wherever desired or of being carried by transfer tickets to almost any point, to which may be added, the absence of the discomforts of smoke, dust, and cinders. Except in the case of comparatively long runs, the greater speed of the ordinary railway train does not seem to give it any material advantage in a competition of this kind.

SOME of the most valuable practical information which has found its way into the columns of the technical journals, in reference to the conditions of economical operation of electric-lighting power and railway plants, has resulted from investigations carried on by advanced students of the different technical colleges, with the cordial coöperation and assistance of the officials of the commercial companies operating such plants. Considering that not infrequently the prosecution of such work is necessarily attended with considerable inconvenience and expense, the enlightened self-interest, if no higher motive, that provides such admirable facilities for researches, which would otherwise be impossible, cannot be too highly commended.

A NOVEL and effective use of the incandescent electric lamp for advertising purposes may be seen nightly upon a huge blank wall south of Madison Square in New York. An illuminated sign of 107 letters, illuminated by 1457 white, frosted, red, blue, and green electric lamps, is arranged in seven different sentences, each sentence being on a separate circuit controlled by an individual switch. An attendant is kept busy from dusk until nearly midnight in causing these sentences to vanish and reappear. It is altogether probable that this functionary will have his job taken away from him by an electric motor which will operate the switches automatically, as soon as the ingenious constructor of the sign happens to think of it.

IN a paper read before the American Society of Civil Engineers, Mr. Lewis Kingman has given some apparently trustworthy figures relative to the much-vexed question of the actual cost of arc lighting by a municipality. Mr. Kingman states that in Topeka, Kan., for 672 nights, with an average of 8.08 hours running per night, the cost per lamp per night works out at about thirty cents. This includes cost of coal per month and per indicated horse-power, oil, waste, carbons, repairs, insurance, superintendence and labor. It does not include taxes nor depreciation as distinguished from repairs. This is considerably more than most of the New England cities pay for having the work done by private companies. The Topeka plant has 184 arc lamps and 33.5 miles of wire, and the average electric power required, as determined by tests, was 440 watts per lamp.

AT a recent meeting of the Canadian Electrical Association the statement was made by a member, apparently upon good authority, that of the $1,000,000 invested in the Dominion in the electric-lighting industry only $400,000 was paying dividends, the remaining $600,000 not only returning no profit, but in many cases showing a loss of original capital. A schedule of the prices received in different towns

and cities for arc lighting was presented, which throws some light upon the cause of this unfortunate result. In one large city of the Dominion, the price is given as only 22 cents per night, and there are very few places in which it exceeds 30 cents. It requires favorable conditions, good management and a large business to make such prices even moderately remunerative.

THE New Jersey Electrical Subway Commission has called upon all the electric companies doing business in the State to furnish information as to the length of electric conductors respectively in use by them, and has notified the corporations having overhead lines in the cities of Jersey City and Newark, to attend a hearing in September on the question of placing the wires underground in those cities. The new law makes it illegal to erect overhead wires in or across the streets of any city of the State without the consent of the Board.

ONE of the most complete and costly electric outfits thus far proposed is under contract to be placed at the eastern portal of the tunnel about to be excavated by the Atlantic-Pacific Railway Tunnel Co. on the new short-line between Denver and Salt Lake City. Electric power is to be used, not only in lighting and drilling, but as the motive power for propelling the cars for carrying rock and ore from the tunnel. The Anaconda Mining Co., of Fremont, Col., and the Idlewild mine in El Dorado county, Cal., are also being fitted up with electrically-operated drilling machinery. It begins to look as if most of the machinery of the Rocky Mountain regions would ultimately be driven by what the space-writers still persist in calling "that mysterious and uncontrollable force," although as a matter of fact we know of no "force" that for mysteriousness and uncontrollability can compare with that which apparently impels the space-writer himself.

THE secretary of the American Institute of Electrical Engineers proposes to commence the publication of a monthly index-digest of the current issues of patents relating to electricity and magnetism. The patents are to be classified by subject-matter and provided with numerical and alphabetical indexes.

EXPERTS of the British Board of Trade are engaged in the determination of the weight corresponding to the attractive force exerted by one ampere of current under fixed conditions. It is stated that the results will shortly be made public.

THE introduction of electrically driven coal-cutters and other mining machinery is making rapid progress in the bituminous mining regions of the central west. The importance of this line of work will be apparent from the figures of production, which show that last year 150,000,000 tons of this coal were mined in the United States, principally west of the Alleghenies.

IT is stated that the Ontario legislature has leased the electric-power rights on the Canadian side of the Niagara river for a hundred years to the same company which is operating on the American side. The price paid is reported to be $25.000 per annum for the first ten years, and $30,000 per annum for the remainder of the term. The vicinity of Niagara Falls is evidently destined to become one of the great manufacturing centers of the world.

THE Virginius Mine near Ouray, Col., is situated at an altitude of 12,000 feet above sea level. All the fuel used was formerly packed up the mountain on burros at a cost of $15 per ton, entailing an aggregate expenditure for this one item, of $36,000 per year. Now the whole work is done at a comparatively small cost by electric power transmitted by wire from a creek four miles distant.

IN a new electric station recently completed at Springfield, Ill., the lightning-arresters are so placed that in case of the formation of an arc by lightning they can be enveloped in live steam. Experiments have shown this to be a most effective means of extinguishing electric arcs.

# MECHANICS

*Conducted by Frederic R. Hutton.*

IS the United States Patent Office and the use of it, a help or a hindrance to the progress of industry and engineering? The question may be argued on both sides, and from the standpoints both of what it is and what it ought to be. The argument against the monopoly given by an authenticated patent comes mainly from engineers and designers called upon to meet and solve special problems, who find the direct avenues to their cheapest and most satisfactory solution blocked by what they are pleased to consider as an obstructive "crank" waving a patent in one hand and an assumed absurd demand for compensation in the other. The result is either a vexatious delay incident to the compromises for a bargain, or a new device "to get round the patent." In the first alternative the solution of the problem is made more costly, and in the second the machine or device is not as simple or as easy to maintain as if the complaining designer had been free to go his own gait. The historic example of this embarrassment is the compelling of James Watt to convert his reciprocating motion at the beam of his engine to rotary motion at the shaft by means of the "sun-and-planet" gear instead of using the more convenient and cheaper crank, already patented by another. When the crank became unrestricted, the cumbrous planet gear was discarded.

If we concede any property-right in the product of a man's own brain, the rejoinder to the foregoing argument is not far to seek. The argument is the same as may be supposed to be urged by large fish against the shallow waters in which the smaller fry can swim secure. The objector finds himself possessed of both brains and opportunity in connection with a large enterprise to make his personality and capacity tell upon its development. The prior patentee having brains but perhaps not opportunity is by his patent protection brought up more nearly to rank with his fortunate colleague, and the latter is forced to recognize him and show him consideration. Perhaps the larger fish does not fancy it much; but the smaller and more numerous fish are surely the gainers.

The most usual argument in favor of a patent system and its protection is much of the same complexion as that advanced for a protective tariff. The security offered to capital entrenched behind a valid and adjudicated patent encourages it to venture upon the outlay in buildings, machinery and experimental plant generally, which must precede the putting upon the market of any industrial product, in faith that the exclusive manufacture and sale of such product can be made to furnish a fair return upon the preliminary outlay. Without such protection there is nothing to prevent a copyist of the original conceptions and devices duplicating the first plant, and by profiting by their outlay in experimentation and failure, succeeding in erecting a competitive enterprise under the same or more favorable business conditions, and either dividing the market, perhaps none too large originally, or forcing prices and profits down by fatuous competition below legitimate and necessary margins. Under these circumstances the first to feel the pressure is the very operative or artisan class of mechanics whose high position and character is a pride of America. In the absence of this protection also, the practice must prevail of habitual and persistent concealment of knowledge obtained by experience and research. The country instead of having a repository or archives of technical processes accessible to every one who may have occasion to consult them, so that each new investigator may begin where his predecessors left off, drops back at once to the repressive individualism of the old guilds as a pre-

ferred policy. The industrial establishments close their doors to friendly visitation of the public, lest a competitor should profit by something they know; father passes to eldest son alone the trade secret of his specialty; and money is wasted in many separated establishments in fruitless duplication of experiment, which might enrich the community if distributed in wages, and might have been saved from waste if only in a patent claim the first pioneer had recorded his successes and hinted at his failures.

The free-trader in the patent field will rejoin that the investment in plant and machinery and garnered experience of the first comer into the manufacturing arena constitutes all the safeguard necessary for such investment. No one, he says, will be induced to sink good money into plant when some one else is already reaping with joy the return which follows the earlier sowing, in tears and delays. If this were generally true, it might receive more consideration, but every manufacturer can recall at once many instances where the very success of the first-comer in meeting or creating a demand, is the very inducement which attracts competitors to his injury.

The most valid and satisfactory argument in favor of our present system and of the improvements desired for it, is the fact that the number of patents taken out by a nation is a certain index of its industrial predominance. It is aside from the present question to discuss fully the relation of these two as respects cause and effect. It may be true that a nation which is industrially preëminent, will for that very reason take out the greatest number of patents; but it is undoubtedly the fact, on the other hand, that the rewards which are offered by an efficient patent system are a very potent factor in such increase in the numbers issued. These rewards are substantial when a fortunate patentee finds himself able to sell to a manufacturing concern the product of his thought and study at a sum which he considers adequate either in money or in stock of the corporation. There is moreover, particularly in small communities, a distinction which is conferred upon him who has obtained from his Government that recognition which is conferred by the possession of a patent. He becomes a member of the intellectual aristocracy of creators—he is recognized as a rising young man, with possibilities to exert an influence (possibly obstructive and sometimes misused) upon the manufacturing interests of the entire country, if his patent should happen to concern one of them; and the subtle flattery which is meted out to the patentee is a stimulus to emulation on every one within his sphere. Furthermore, it is a fact that the countries where the patent system is inefficient or inactive, of which Spain and Turkey perhaps are illustrations, are the places where the industrial development lags most seriously behind the van where the other nations lead. So that in spite of all necessity and capability for improvement in our existing patent system, it seems fair to conclude that its general effect is good and healthful.

WHEN the interest among the naval and stationary engineers is so continuously directed to the question of utilizing oil as a fuel under boiler furnaces, it is interesting to observe something of the relative economy under favorable circumstances of coal and oil. In New Jersey, in competition with anthracite slack and Westmoreland coal, it has been found that if the oil be at 2.4 cents per gallon, it would compete with coal at $3.95 per ton, at a test of a 6000 horse-power boiler plant. With coal at $3.10 per ton, and oil at 2.25 cents per gallon, the coal was cheaper. And where, in the coal district, that fuel could be gotten at $1.50 per ton, and oil at 1.5 cents per gallon, the oil cost one-third more than the coal. The theoretical evaporation of ordinary oil is about twenty-one pounds of water per pound of oil, and they have been experimentally able to get 16.7 pounds of water per pound of oil 63° B. in New Jersey, and in New England 17.8 pounds of water to steam at ninety pounds per pound of oil. This evaporation is secured by that method by which the oil vaporized to gas in a retort is carried forward to meet warmed air at the burner. A much more efficient combustion is obtainable than

when the oil comes as a fluid to the furnace; and many of the difficulties connected with the fouling of the heating surfaces are avoided.

THE uplifting effect of that engineering activity which has developed and extended the use of machinery and the natural forces in industry has not always received the attention from economists which its importance deserves. In the older civilizations when great works were to be constructed, the contractor was compelled to dependence upon hordes of slaves or serfs, working by mere brute force under scourge and goad. The valuelessness of a human life under the conditions existing when the pyramids were built, or the baronial castles of the middle ages, is a thought which is painful to the Christian student of progress, and the increasing value put upon human service and labor is one of the hopeful signs of the later centuries. Leaving aside those avocations calling for a trained and skilful operative, and looking only at the use of human brawn without necessary brain in such mere labor as is involved in the moving about of heavy weights and masses in shops or yards of manufacturing concerns it will be safe to take the lower figure, for the working capacity of a man laboring at such pulling and hauling for a day of nine or ten hours, and to estimate his capacity at less than one-tenth that of an engine horse-power. The engine horse-power does not fag at the end of the day, but the man's endurance and willingness is sure to do so. If the man takes only the three holidays of Thanksgiving, Fourth of July and Election Day besides his calendar Sundays, his working days will be 310 in the year if he is independent of weather, and outside of the cities, where living expenses are correspondingly reduced, his employer is likely to pay him $1.50 per day for his mere brute strength. The employer therefore pays for $\frac{1}{10}$ of a horse-power of energy at a yearly rate of 310 x 1.50=$465 or for the ten men who would aggregate the one horse-power, the outlay must be $4,650 per annum. The same force from a steam engine could be obtained from steam or water according to figures given by Emery. Manning or Main at prices ranging between $25 and $65 per annum, under the conditions which prevail in New England or the Middle States. The economic result under the action of the laws operative in such cases must be the replacing of the costly human labor by the cheaper natural force; in sequence, the cheapening of the cost of manufacture, a greater output and sale at the lower rate as a larger market of consumers is reached; a call for more human labor and more intelligent in quality to supply the increased manufacturing demand, which labor of course is more highly paid and attains a higher grade of recognition and competence, and the standard of living and civilization rises with such improvement in the individual. It is at the period of the first transition that hardship and obstruction may be met, before the new conditions have had time to bring back into the labor market the first savings of the wage fund. It is at this period that the Arkwrights have their spinning-frames wrecked by the hand-spinners and the inventors or engineers who project improvements are the objects of enmity and violence. Under the later conditions, they attain their deserved recognition, withheld under the stress of the first struggles.

Under many conditions the amount of work of the pulling and hauling type is not sufficient either in amount or in continuity to keep a steam- or water-plant sufficiently busy to pay for itself. Under these circumstances, the engineer turns to seek some of those forces which cost only for interest and repairs and attendance, or on his path to such a solution he stops to consider the use of horses in tread or other horse-powers. In the Middle Atlantic States the cost of a horse used for work of power purposes usually will be made up of items averaging as follows:

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|---|---|
| Interest and renewal fund, 10 years, on $150 | $ 9 00 |
| Feed for the year: hay, 45; oats, 62 | 107 00 |
| Attendance | 45 00 |
| Shoeing and sundries | 24 00 |
| Harness, interest and renewal | 5 00 |
| Total | $190 00 |

which might be called $200 in round figures to take account of any special circum-

stances which might increase this expense. As in the case of man, the horse will not furnish a full horse-power continuously, inasmuch as the 33,000 foot-pound unit is a large one for the ordinary type of work horse, since it was based upon the performance of a particularly powerful variety of draught animal in the first instance, and the horse becomes also less able and willing as his work-day advances. The horse-power therefore will cost 8 or 3 times more than the force of nature made available by the skill of the engineer, while much higher both in the economic scale and the scale of civilization than the use of the human animal.

IT was Emerson who spoke of the ideal industrial epoch which should be reached when the natural forces should be so perfectly harnessed to the use of man that the farmer should be able to reach his market by "hitching his wagon to a star." It is in this field of effort that they labor who are trying to utilize by windmill or by wave-motors the immense and apparently wasted energies which are observable in unceasing activity in the restless wind and the heaving ocean about them. Leaving aside for the moment the consideration of the wind-motor, and confining attention to the utilization of the power of ocean waves, the attention of engineers has been directed anew to this subject by a very able paper presented before the American Society of Mechanical Engineers by Mr. Albert W. Stahl, one of the naval constructors in charge of work for his department on the Pacific Coast. As in the case of the condensing steam-engine, so also in the matter of wave-motors, the high price of fuel on the Pacific slope has had a powerful effect in stimulating invention and the securing of patents looking to improvements as well as to new devices.

THE motors for utilizing the ocean have been of three great classes: the first are tide-motors, where a wheel is driven by the head of water, which is the difference between the level of the ocean outside of a wall and the water inside that wall in a suitable pond or reservoir. In an opening in the wall is a wheel which is turned in one direction as the tide rises to flow into the enclosed space behind the wall, and turns in another direction as the water flows out. Perhaps even a simpler form is that of a simple dam with a gate opening inwards from the sea, which is opened by the inflow of the tide, and upon its ebb that same water flows out through the wheel sluice.

The second great class of motors embraces those utilizing the impact of the wave against a vane or similar surface which should be moved by that impact and transmit its motion to the rest of the machinery. This is a form of motor which must have suggested itself to those seeing the immense energy with which the breakers dash against a rockbound coast.

The third type is that which is discussed in Mr. Stahl's paper, where the intention is to utilize the motion of the wave proper as the force of the water manifests itself to a vessel afloat upon the wave. This form of motor has great advantage over the impact type, in that from the nature of its conception, the motor itself as distinguished from its supporting frame-work, is not liable to the injury which the unbridled excess of stormy and irregular waves may bring to bear of power upon the motor.

THE discussion of the subject of the utilization of ocean waves in the form of a motor approving itself to Mr. Stahl naturally attacks first the various motions of the water which may be utilized, which are found to be three. The first is a vertical rise and fall of particles at or near the surface. It is this motion which all forms of wave-motors using the principle of the float endeavor to secure and apply. That this power is neither small nor inadequate appears from the immense weights of vessels which the up-and-down motion of the water so easily lifts as the waves pass. The difficulty with the float system, however, is that the float has to be of great size for large powers. As its size increases so also does its weight, and with increased weight the action of the wave becomes proportionately less efficient.

The second motion of the water is a horizontal swinging motion of particles at and near the surface. This type of motor calls for a suspended vane moved backward and forward as the waves advance and recede, which motion is carried ashore by suitable linkages.

The third motion is that which results from the variation in the slope of the wave surface. This requires that a suitable float, coupled to its supporting and steadying frame-work by two or more of its points, shall transmit the motion which results from the variation of its level, which of course remains essentially normal to the tangent to the curve of the wave.

The fourth motion is the impetus which is given to the waves as they roll up a beach in the form of breakers. These are utilized either by a carriage running upon a track, or else by permitting the wave to force itself through a converging surface by which the air in front of it is compressed and forced out of the way.

The fifth is the motion of distorted verticals intended to be normal to the wave surface when the wave is at rest, but moved from the vertical as the wave passes the vane. This latter plan is the one which Mr. Stahl prefers; and it offers the great advantage that its power increases as its size; that it will utilize the amount of power which it can take upon its surface, and will not be wrecked by the excess of the wave action in storms.

The difficulty which has to be met in all forms of wave motors is the difficulty of adequately securing the necessary frame-work by which the moving members of the motor shall be supported, so that the motions of the motor can be made definite.

THE wave-motor requires in addition to the submerged part of it that there shall be suitable regulating devices to obtain a uniform motion from the irregular or even spasmodic action of the waves, as well as such appliances as may be required for the adjusting of the apparatus to the state of the tide and the condition of the sea. There must in addition be the necessary storage appliances or arrangements, in order that a continuous supply of power may be available when the waves are calm, or their motion, due to the direction of the wind, comparatively small.

The questions which attach themselves to this matter of the storage of power are so broad and far-reaching that they deserve a separate discussion by themselves without attaching themselves merely to another subject as a corollary thereto.

IN the field erection of girders or other similar riveted ironwork, the problems of securing an adequate riveting power deserve consideration. It is usual in specifications to call for a greater rivet area where hand-work is compelled in order to compensate for the uncertainty of this class of work as contrasted with the machine job. Of the portable riveters now in use, the air or pneumatic riveter and the hydraulic riveter seem to be the only ones available; and the hydraulic riveter is at a disadvantage in a place where the temperature outside may fall low enough to endanger the apparatus from freezing. Both devices compel a plant on the ground of some magnitude and especially intended for the work in hand.

These considerations give especial interest to a form of power-riveter which has just been put upon the market by Delaloe and Piat, of Paris. The principle of this riveter is to have a piston moved slowly forwards by a speed-reducing gear from a revolving armature of an electric motor. This small piston compresses oil upon the surface of the riveting ram on the principle of the hydraulic press, so that a pressure of two tons per square inch on the small piston upon an area of sixteen square inches on the riveting ram gives a riveting squeeze of thirty-two tons. The motor required is only the ordinary one for a 110-volt current using about 25 amperes for the period of two or three seconds at each rivet.

It is obvious that as the machine requires only lead wires they can be carried from a considerable distance even from the nearest town, and either naked wire conductors taken the whole length of the br dge can be tapped by the necessary in-

sulated wires to the machine, or the insulated wire with abundance of slack can be used direct, as may be found more convenient. The wires certainly take up much less room than the flexible pipes necessary on the other systems.

IT has been known that the continual exposure of iron to heat and its sudden contraction by cold thereafter, as in the tempering process, would result in a change in the bulk of the piece so exposed. This difficulty has precluded the satisfactory permanence of pyrometers depending upon the principle of the expansion of metals by heat. After a certain period the index would refuse to come back to zero as the result of a permanent change in the length of the bar. The difficulty which is met with in boilers from the sudden contraction of overheated tubes and which results in leakage at the tube sheets gives especial interest to a set of experiments reported in London *Engineering*, undertaken by Mr. A. Blechynden, of Barrow. Two tubes were tested together, one of iron and the other of steel, which were of the same length when at 46 degrees Fahrenheit, but after three heatings and coolings, there was found to be a difference of nearly $\frac{1}{10}$ of an inch in a length of fifty-five and a half inches. But an experiment of even greater interest was to take two similar tubes of iron and steel expanded into a reamed hole at each end, the whole put into a furnace and then dropped into water, whereupon it was found that the steel tube was so slack in the hole that when water was poured on the outside of the tube it would run through between the hole and the tube, while the iron tube remained tight. The steel was Siemen's Martin metal, such as is generally used in English boiler practice, while the iron tube was of Scotch make. We are not told in the reported experiments whether the plates into which the tubes were fitted were of iron or steel, but if of steel, it would perhaps show a reason for the opinion which prefers iron tubes even in a steel boiler.

AN interesting event in railroad circles has been the change of the last division of the main line broad-gage system in England to the standard width. It will be remembered that the Great Western Company of England, under the management of the great Brunel, had made its entire line with a 7-foot distance between the rails. The standard prevalent in the rest of England is that to which we are accustomed in this country of 4 feet, 8½ inches. In addition, however, to the distance between the rails the Brunel system used longitudinal sills or stringers under the rail, which were in most cases of the bridge type, weighing about sixty-eight pounds to the yard. The longitudinal stringers were 11 inches wide by 6 inches deep, connected together at intervals of eight or ten feet by transverse members tenoned into the sides of the sleepers while wrought iron tie-rods passed through the sleepers at intervals to keep the gage and to hold up the transverse members. The change was all made between Saturday morning, May 21, and Sunday afternoon, the 22d, some 5000 men being employed in gangs of from fifty to seventy, each gang being apportioned to two or 2½ miles of track. Traffic had to be suspended, inasmuch as there was no possibility of laying down a third rail in view of the absence of the necessary transverse ties, so that there would have to be the necessary longitudinals laid anew for this purpose exclusively. The work involved four principal operations: The removal of ballast, shortening the transverse members and tie-rods, the sidewise displacement of the longitudinals with the rails on them, and the bolting up and rough-ballasting. It is the intention of the company to do away with the longitudinal system, and replace it with the ordinary transverse tie, which has been found to give all necessary stability and stiffness, and to be less trouble to maintain.

# ARCHITECTURE.

*Conducted by Barr Ferree.*

THE notable series of papers on European capitals which Dr. Albert Shaw is contributing to *The Century* contains much interesting matter illustrative of the importance of architecture as a factor in current life. As every one knows, since a city is an accumulation or aggregation of buildings, it must necessarily contain many examples of architecture, but every one does not appreciate the fact that there are many questions of municipal growth which influence architecture in a very direct fashion, and none the less strongly because the influence may never be so much as suspected. Dr. Shaw brings out the relation of the municipality to architectural development in a very strong manner, perhaps more so than he intended. His studies in municipal government have proved a great help in the diffusion of ways of doing things as exemplified in one of the most serious problems of modern government; it is not less important to note the effect these regulations and forms have upon architecture. In the paper on Budapest Dr. Shaw points out how essential the architecture of a city is to its apparent wealth and progress, showing, in other words, how very clearly architecture, even in this practical age, can be influenced by causes which are not architectural. The lesson is one that may be learned at home without going to southeastern Europe for it, though Dr. Shaw's travels will have accomplished great good if they do nothing else than enforce this fact. Unfortunately no American city can point to such a monumental series of buildings as make the splendor of Paris, Vienna or Budapest. American tastes may not be less luxurious than those of Europeans, but they do not take architectural form. New York is said to possess at least two individuals whose incomes exceed that of any European sovereign, with a host of personages of less financial standing, whose incomes are quite as large as many of the oldest and richest of European families. Yet the residences of the richest New Yorkers cannot begin to compare, in external magnificence, with the palaces of European families of equal or even lesser wealth. Many of these splendid dwellings which delight the eye of the American abroad represent the results of years of hereditary occupation, with occasional buildings and rebuildings. In this country, however great may be our tendency towards an aristocracy of wealth, we are too young to have family palaces which shall represent the accumulation of years as well as the accumulation of wealth. The future may change this; at present we have to do with what we have.

THE effect of this is visible in several ways. First, there is a serious loss to the dignity of American streets by the lack of monumental residences for our wealthy citizens. Perhaps in each large city there may be some one especially noteworthy dwelling, but the most stupendous of these makes no show at all when placed in comparison with the great houses of European capitals. Doubtless the most elaborate American residence is as satisfactory to the persons occupying it as many a less pretentious one to those who live in it, but we cannot have magnificent streets without magnificent buildings to give them a setting and make them dignified. Pennsylvania avenue in Washington is admittedly one of the finest streets in America, yet its dignity and its fame come almost wholly from its great width. Lined with palatial structures, such a thoroughfare would indeed be a splendid example of city grandeur. Very much the same may be said of the Fifth avenue, which New Yorkers are fond of referring to as the greatest street in the new world. Yet its most ardent admirer cannot pretend that

the buildings which line it are, as a whole, worthy of the locality or even of the people who live in them. The small lots, used even by the wealthiest families, are fatal to architectural grandeur. Each man building for himself, in what design he pleases, may present most admirable opportunities for the display of individual taste, but however good the design, it creates variety only, without the dignity which could be produced by widening the façades. Even the block of Vanderbilt houses, which covers more ground than any similar group in the metropolis, loses a good deal by being cut up into several sections, forming apparently and in fact several distinct dwellings. Perhaps it is too much to look for any remedy in the present state of American families, in which too often the structure built in one generation passes into strange hands in the next. This is perhaps less so in New York than in other American cities, but if such changes are not brought about by changes in fortune, they are apt to be hastened by changes in fashionable localities and the constant search of the rich for exclusive situations. The changes in fashionable localities in New York have been very rapid, and while it is customary to point to them as indications of the city's increasing prosperity and wealth, it is well to remember that admirable as they may be from this standpoint, they effectually put a stop to permanent architectural improvements such as may be found in European cities.

ALL this, it may be said, represents American push and energy. It also represents the want of appreciation of architecture, which is so sadly characteristic of American life and manners. In this country we have not yet realized the value of externalities in our cities. Each man building for himself, as he chooses and in the way he chooses, forgets that if there were some one general policy governing the erection of monumental structures his cities would be more attractive, and his own esthetic sense less offended by the strange and curious sights presented to the eye of every traveler. A certain amount of improvement may be looked for in this respect by the increased number of great structures devoted to business, but these can never have the value which may be obtained from imposing private residences and great public buildings. In the matter of public buildings we are notoriously so much behind many small European cities, that our municipal buildings are more often a byword among critics than examples of architecture, which should be a joy for all. The largest of business blocks can only give the dignity of width and height, with small pretension to genuine architectural feeling, since here, as everywhere, business is business, and architecture and decoration and art and beauty and esthetics very minor considerations that scarcely call for mention in the pages of the illustrated magazines. And this is the root of the matter, the cause of the whole trouble. We do not lack imposing structures because we cannot make them, but because we do not, as a people, understand or appreciate their value. Some day this will doubtless be more generally understood, and in the meantime the glory of American architecture will remain in the solution of business problems, problems of great practical utility and importance, but constructive problems rather than those which may be properly called architectural. This is the line in which American architecture is now tending; in it we have made our greatest triumphs, and in it we shall continue to do so, until these hard limitations have been thoroughly grasped, and the possibilities of architectural art widely understood, when we may perhaps be able to eclipse the rich cities of the old world by the grandeur of the new. But how much our cities lose in the process of evolution!

THE architecture of the World's Columbian Exposition at Chicago has been so extensively illustrated in the technical journals that criticisms are coming in from every source. Foreigners have had opportunities of observation and criticism, in the numerous articles and pictures with which the press is flooded, to estimate the architectural value of the buildings. It is not to be expected that the general satisfaction with these buildings which has been ex-

pressed in this country should be reëchoed abroad. English critics, especially, are prone to find fault with things American in America. It is quite natural that others should look at our work in a different way from that in which we view it ourselves, and it is possible that a foreign estimate may be more correct than an American, since the satisfaction which an American naturally feels with the work of his own country cannot bias a foreigner. Yet it is doubtful, from the cautious way in which the English critics look at the architecture of the approaching Exposition, if they approach the question in the right spirit. Buildings for a world's fair, lasting six months only, should not be measured by the same canons as would be applied to structures intended to last a lifetime. The temporary character of such structures necessarily implies a criterion of their own by which they must be judged. It is much easier to find fault than to produce perfection; hence it is easier to point out wherein the Chicago buildings might be improved than to prepare faultless designs. It is not to be pretended that these buildings are incapable of improvement, but it is clear that they serve their intended purpose in a very good manner, that for temporary structures they exhibit sufficient dignity, which is the more important by reason of their gigantic size, and that they have sufficient homogeneity, without being too similar, to compose, on the whole, a very satisfactory group. In fact it is the success with which they meet the question of temporary use that wins them most praise in this country, and as it is this which has called them into existence, it is this which should form the basis of every intelligent criticism. Our English brothers should look more closely at the *raisons d'etre* of the Chicago buildings than at their relative merits or demerits as designs on paper. It is not in accordance with American thrift, or with common sense, foreign or domestic, to erect monumental structures for a few months' use. It is wiser to congratulate ourselves on having obtained so good a series of buildings than to spend time in pointing out wherein they might have been improved.

THERE has been manifested recently a most alarming outcry against architectural writing in certain quarters which is doubtless intended to carry dismay among the host of non-professionals who undertake to describe and judge the architecture of America. Not long ago *The Nation*, in reviewing Mr. Montgomery Schuyler's book on "American Architecture," stated that the author was one of the very few writers not professional whose remarks carried any weight. *The American Architect* quickly echoed the same thought in characterizing "the light criticisms current in the magazines" as "usually written by men without professional training." Without undertaking to defend the non-professional writer, it may be pointed out that a limitation of architectural writing to architects would result in a most uncalled for restriction in it. There is no reason at all, as both *The Nation* and *The American Architect* are aware, why an architect is necessarily better qualified to write on architecture than one who, though not an architect, has given the subject careful and intelligent study. Dramatic critics are seldom actors; critics of painting and of sculpture are as seldom artists; why should architecture be a sacred art that none save architects may speak on it? It is true enough that there is much printed about architecture that should never have been written; and it is also true, as every observer must have noted, that many buildings have been built that should never have been designed. If architects fail in their particular province, what may be expected if our whole architectural instruction is to come from them? Professional literature in this country is far from being what it should be, and is confessedly inferior to that of England, France and Germany. Even our technical journals, in which the literary productions of architects may most naturally be looked for, are made up chiefly of foreign material, either in the form of translations or in direct borrowings. Admirably edited as some of our architectural journals are, their contents are largely reproductions from foreign sources. A leading British journal before me, on the other hand, is filled with important papers, re-

ports of original lectures and discussion, and notes and articles of the most varied kind from practical architects. The difference is not altogether in editorial management, but in the greater attention given to literary subjects by English architects. Perhaps they have more leisure than American architects; perhaps they more keenly appreciate the value of professional literature. Whatever the reason, we have in this country no such professional writing as may be found abroad.

What, then, is to be done? If our architects do not write, shall we do without architectural discussion, or shall we make the best of non-professional writers? The question is not more unnecessary than the criticisms made by the two periodicals above. If the architects will not write, the non-architects cannot be blamed for filling a gap in the literary world. And as a matter of fact the advancement of architecture in this country owes a debt of no inconsiderable magnitude to the non-professional. Architecture is a subject about which there should be the greatest possible interest, but in which comparatively little interest is felt. Yet this interest is growing wider day by day, and largely through the popular magazines which are constantly giving more space to architectural subjects. The value of the criticism contained in this space is quite foreign to the value of exhibiting architectural models where all may see them. The non-professional writer has, therefore, acquired an importance, perhaps unjustified and unmerited, but nevertheless an importance which the professional man has not obtained. It is altogether needless to insist that competent writers on architecture can only be architects. It would be as sensible to maintain that a diploma of the American Institute carried with it a certainty that the designs of the prossessor would be above even professional criticism. There is unquestionably much room for improvement in architectural criticism from lay pens. There is too much attention given to superficialities, to the manufacture of façades and the grouping of masses, to the exclusion of the real conditions—hard, practical, difficult conditions—which hem in and surround the design of every modern building. But it is one thing to insist on this improvement, and another to deliberately shut out all but architects from saying anything about an art that affects the life and well-being of every civilized man. Architects, no more than other men, should not produce work that will fail to come up to the standard of non-professional writers.

The subject touches on the whole question of architectural criticism. Nothing can be more evident than that of all men architects are most unfitted to criticise current architectural work. No critic can justly judge the work of a personal friend; no architect can rightly estimate the value of the work of a business associate or professional rival. The blowing of one's own trumpet has become a recognized feature in all callings, but the architect who would write himself up in the press would speedily find his reward to be other than he hoped. Architectural critics cannot be gathered from professional sources. As a matter of fact all wholesome criticism should be anonymous, and that not nominally so, but absolutely and entirely. The moment a critic is known, be his judgment ever so just, his fitness for his work ever so great, his remarks lose part of the weight of authority. It is Jones's opinion, or Brown's; it represents individual views, not authoritative utterances. A well-known writer on architecture has laid down the rule that before beginning to write on any architectural subject the would-be author should visit architects, find out what they are doing, get their opinions, and have a "talk" with them. Under certain conditions this advice is wise and good, but how, pray, is one to point out errors, and possibly glaring ones at that, in the work of a man with whom he has just had a friendly conversation, who has taken him into his confidence, as it were, and brought out all the good points of his work? There are many lines of work which only professionals can rightly criticise. The engineer understands the problems of his profession better than the layman can possibly do. It is the same with the electrician, the machinist and

many others, because in these professions the questions are wholly utilitarian. Architecture does not come within the same category. There is a personal and inventive phase in it which destroys the value of external criticisms, if no other, from professional sources. The non-professional writer may not come up to the necessary standard, but he performs a duty that the technical journals may well be thankful for.

THE Rev. Dr. Huntington finds great comfort in the fact that no voice has yet been raised in protest against the accepted design of the choir for the new Episcopal Cathedral it is proposed to build in New York. As a matter of fact no intimation has been given that criticisms would be acceptable or that they would be heeded had they sufficient weight. It is more likely that the silence in which the reverend gentleman finds so much joy arises more from indifference than from any sense of satisfaction. Doubtless it is now too late to make any changes in the accepted plans, but it may not be too late to point out one or two points in which something better might have been hoped for. If Dr. Huntington would take photographs of the apse and choir of Notre Dame at Paris, of the cathedrals of Amiens, Rouen, Chartres, Reims, Le Mans, Cologne or Canterbury and compare them with the drawings of the same parts of the New York cathedral, he would find some parts in which the home design falls immeasurably below the others. For the question is not a matter of style, but of relative magnitude and superiority. The New York cathedral is to be not only absolutely great but relatively also. The whole conception rests on an attempt to rival the great churches of Europe. Doubtless this can be done without servile reproduction or too close copying, but having selected a style of architecture that approximates in general appearance, however different and distinct it may be in detail, the great churches of Europe and then accept so bald a closing as is shown in all the drawings of the accepted design, is simply ignoring the plain teaching of real structures. It is very hard for the Episcopal clergy in this country to rid themselves of the traditions of Anglican church architecture, of flat wall endings, suggestive only of a lack of ideas, but very English and very dear to the Anglican heart. As a flat wall has no particular architectural value as an end to the long vista of a church nave, it might be supposed to have some special religious significance. This the most violent Anglomaniac cannot assert with any regard for his own intelligence. The New York cathedral trustees have avoided this error, but it is to be regretted that in doing so they did not obtain something so much better, finer, grander than they did.

THE most munificent gift yet made to the study of architecture in New York is the Avery Library of Columbia College. Founded by Mr. S. P. Avery, in memory of his son Henry O. Avery, and handsomely endowed, this great collection of books fills more than a vacancy in professional needs of the metropolis. Though not yet ready for general use, the exhibition of the collection, which formed a feature of Commencement week at Columbia, brought out its great wealth in books for the first time. It has been planned on the most liberal scale, the idea being to obtain representative books in every phase of architectural and decorative work. It is not, composed therefore, of books exclusively architectural, but very well illustrates decorative, archæological and allied subjects. It is needless to say that the library contains many volumes not to be found elsewhere in New York, if indeed they can be found anywhere in this country. The great cost of many of the most pretentious and valuable books on architecture is almost prohibitive, and hence it is impossible to estimate the good that must follow the opening of a collection in which expense has been a secondary consideration in forming a thoroughly representative selection. The book exhibition was a revelation both of the wealth of the library and of the richness of architectural literature, and was of value not only in directing the professional man to the treasures

placed within easy reach, but of illustrating to the greater public the possibilities and actualities of architecture. One department of the library calls for special mention, because destined in time to become one of its most valuable features, and that is its series of periodicals. No class of journals is so rare in our public libraries as series of architectural and archæological periodicals, journals of societies, records of meetings, etc. This has been made a special department of the Avery Library, and it is hoped to make it, what indeed it is already not far from being, the most exhaustive collection of the kind in America. The generosity which prompted this noble gift will be appreciated more and more as the collection grows older and more complete.

WHO but a Frenchman would think of writing a history of candlesticks and lamps and methods of lighting in general? Certainly no one but a Frenchman could carry out such a work in a lively manner and clothe dry historical facts in animated language that would attract both student and amateur. Strange as the subject is a French writer has prepared a "Histoire de Luminaire" in which he traces the manner of making illuminations from Roman times to our own day. And when one comes to think of it the making of a gas standard or of a chandelier or a lamp is quite as important, in a well-ordered and correctly-designed house, as good windows and doors, or even walls and roofs. Yet in this country the making of artistic light standards and incorporating them in the general design of buildings is comparatively recent. Few methods of architectural decoration are capable of more successful handling than this, and few have been worse handled. In much recent work the single artistic idea, if such it can be called, has been the grotesque. Horrible dragons and hideous monsters, which look quite tame when fastened by their tails to a wall, seem to meet the prevailing taste. Of course prevailing taste has absolutely no relation with art or architecture, but these provoking animals of iron and bronze often maintain an existence wholly unnatural and quite out of proportion to their importance. It is when such things are viewed as a whole as in the work just referred to, that the real possibilities and the real actualities of good light fixtures become apparent. The catalogues of the manufacturers of such goods are not always the place to look for artistic reproductions, but they are becoming more satisfactory every day. We need much more than improvements in manufacturers' catalogues, improvements in the art idea. French decorative art is to-day the finest in the world because the artistic instincts of the French people have been cultivated to such a point that they appear spontaneously, as it were. Nothing but the most egregious self-conceit or wilful blindness can make one compare our own little progress with the great strides the French have been taking for centuries, but we can look at their work with longings to equal it if we realize this cannot be done in a day. This is perhaps getting a little far from our "Histoire de Luminaire," but it is so full of admirable French designs, and so well illustrates the French concern for minute details, as to naturally bring up the condition of art in France. The high merit of French art to-day is one of the most noteworthy instances of the results of protection. Constant and persistent encouragement by all kinds of government has placed France at the head of artistic people. It is a striking contrast to the policy pursued by our own Congress and petty politicians.

# CIVIL ENGINEERING.

*Conducted by T. Graham Gribble.*

THE promoters of the Nicaragua canal are pushing the claims of that great scheme before the American people in an energetic manner. The union of the two oceans is a project which appeals to the commerce of the entire habitable globe. It will create a traffic of its own beyond all calculation; it will promote the civilization of the sparsely-populated regions on either side of it and it will bring the means of subsistence to millions who will populate the new trade centers which will be its natural outcome. The United States, from strategic as well as commercial reasons, cannot afford to allow such an undertaking to pass outside its own control. To Great Britain it would have been, to say the least, a better investment than the Slough of Despond into which she has poured her hundreds of millions. Even now in spite of the prodigious losses which she has suffered from the collapse of Argentina there is a glut of capital in England waiting for a revival of confidence. It would not be surprising if the promoters of the Nicaragua canal were soon to receive a tempting offer from London which they could only be forced into accepting by the supineness of their own Government and people.

The General Manager of the Canal Construction Co. read a paper a short while ago before the Franklin Institute of Philadelphia which, besides being a general description of the project, the substance of which is familiar to us all, gave some details of interest that are not so generally known. Mr. Davis stated that the first survey was made as early as 1849 by Mr. Oliver W. Childs of Philadelphia. Since the granting of the concession in 1887 the surveys have been continuously carried on amidst great difficulty from the dense virgin forest and tropical jungle until the present time. Counting up all the trial lines, location surveys and re-surveys a total length of 4000 miles has been surveyed, and the company are assured that they will not fail of success from lack of knowledge of the ground.

The San Juan river which forms the access from the Atlantic is 35 to 100 feet deep and a steamer built at Wilmington, Del., which was brought into Lake Nicaragua through that river, has for eight years been doing the entire trading upon the lake.

The most formidable part of the undertaking is the great rock cut at the divide which is between three and four miles in length and *averages* 140 feet in depth. A great rock cut is generally regarded by the non-technical public as a greater engineering difficulty than one in soft material, but every engineer who knows what wash-outs and land-slides are would infinitely prefer to handle a rock cut than one in clay or sand. The material from this cutting is to be transported by means of the railway now in course of construction to form the breakwater at Greytown.

The locks are to be similar to the great lock at Sault Ste. Marie which has passed 9 million tons of shipping in 234 days, or nearly 50 per cent. more than the Suez canal. The width of the latter canal at bottom is 72 feet, but the Nicaragua canal will have a minimum width of 80 feet and depth of 28 feet. A 3000-ton steamer can be passed through the Soo lock in thirty minutes, but allowing forty-five minutes for the Nicaragua locks, a vessel will be able to make the complete passage from ocean to ocean of 170 miles through canal, basins, river, lake and locks, in twenty-eight hours.

The first estimates of cost by a commission of prominent engineers was about $87,000,000; since then by careful survey and analysis the company believe that the cost will not be more than $65,000,000 but allowing for financing and all contingencies they bring the figure up to $100,000,000 and

believe that the whole work can be completed in six years.

ADVICES from Christiania to the Chicago *Herald* indicate that Scandinavia will furnish the World's Fair with a dragon ship of the Viking period which will make the 5000-mile transit on its own keel and by its own oars and sail. Following upon the voyage of the *Wergeland*, referred to in the June number of this magazine, as the first steamer to make her way from the old world into the heart of the American continent, this enterprise of the hardy Norsemen will be viewed with peculiar interest. The *Gokstad* is to be modelled on the remains of a vessel which was excavated in 1880 on the shores of Sande fjord, at the entrance of the Christiania fjord. Her hull is seventy-six feet long and about sixteen feet amidships. Her oars are sixteen feet long and the rowing crew will be composed of thirty men. There have been numerous applications for the hazardous task of navigating the vessel across the Atlantic. Several literary men will accompany the dragon ship with a view to writing a story of the voyage and publishing along with it an account of the discovery of Vinland (America) by the Norsemen long before Columbus. During recent years the influx of Scandinavians into Chicago has been very great. Whole districts are occupied by them; they have their own churches and places of amusement, but they rapidly become Americanized and form a very worthy and useful element of the population. The exhibition of the Dragon ship will not only appeal to the Scandinavian part of the community, but from its historic value will be a great object of attraction at the Exposition. The ancient practice of providing in the vessel a sepulcher for the Viking, in which he was entombed with the magnificent accoutrements of his rank, will all be illustrated. A sum of $16,000 will be gathered by national subscription to defray the expenses. She will doubtless take the same route as the *Wergeland* via the Saint Lawrence and the Welland canal and may expect a tremendous ovation when she arrives.

IN some recent numbers of London *Engineering* an amusing account has been given of railroading in the island of Formosa in the China seas. The Chinaman finds engineering a splendid opportunity for display of officialism and mingles with it his supreme contempt for the "foreign devil" with the spirit-level. The scheme in its completeness was to include a railway from end to end of the island, with a tunnel and some fair-sized bridges. The rails coming from England, it was found expedient to appoint a British consulting engineer, but the executive was entrusted to a Chinese construction company under Government supervision. This company became hopelessly involved, and the Government then took complete control of the works with their corps of military engineers. The manager of construction was the Governor of the island and every gang was bossed by a live general, the men being soldiers of a military distinction entitling them to be called "braves." It was found after some time advisable to send to England for a resident engineer, principally to come in as a scape-goat when failure took place, but by no means to presume upon his position otherwise than to give advice. Even the location was definitely fixed by His Excellency the Governor irrespective of foreign arguments, the only exception being that when a gang-general had a "pull," he would make deviations to suit his own ends, sometimes involving curves of 150 feet radius combined with grades of 330 feet to the mile. The British resident engineer on arriving, found the work in so disgraceful and dangerous a condition that he made a report to the Governor setting forth all the defects, suggesting improvements and recommending the reorganization of the whole system. His Excellency replied by placing three Chinese officials, one over bridges, a second over machinery and cross-ties, and a third over maintenance, to carry out the engineer's suggestions, *as far as they should deem it advisable*. The greatest of the afflictions of this much-tried man was the bridging of the Twatulia river, 1500 feet in total length. The Chinese insisted on carrying out the work in old-time Chinese style. The depth

of mud had been proved by borings to be at least 120 feet below the bed of the river, but the piles were all cut 50 feet long and driven until their tops came level. This structure was swept away when about one-third finished. Although the railway system of Formosa cannot be said to have done much to add to previous knowledge of the art, it was quickly appreciated by the Chinese peasantry as an improvement upon the Government highway. In the words of the writer:

"No sooner were culverts and bridges practicable for foot passengers, than the railway was inconveniently used as a high-road to and from the capital. Strings of half-naked, groaning and sweating coolies staggered under their cruel loads, suspended at the ends of spring bamboo yokes; while closed paper-covered bamboo chairs, containing local dudes and belles, passed gently bobbing up and down, and became a source of serious inconvenience and danger to the drivers of the trains."

It is a truism to say that it is harder to unlearn than to learn, and yet it has no more striking exemplification than in China. The religion itself, with its chief feature ancestral worship, shows how the Chinaman lives in the record of the Past. The American, on the contrary, deals in "futures."

THE decision of the Supreme Court in favor of the plan for rapid transit proposed by the Commission appointed by the State of New York to solve this great problem is an important step towards some practical result of two years deliberations. The judges' conclusion is that the report must be confirmed and the work allowed to proceed; they say however "that the success of the enterprise is not a question of engineering but a matter of finance." It could hardly be expected that the legal sages were to decide upon whether the plans as presented could be carried out successfully. They have however made short work of the objections, and have supported the action of the Legislature in conferring powers upon a carefully selected body of men to come to the best conclusion in the acknowledged condition of urgent requirement on the part of the general public for improved means of transit. There remains the fact that many engineers of very wide experience have not been able to endorse the plans of the Rapid Transit Commission and the further fact that capitalists have not shown great avidity towards the enterprise. The engineering objections were described at some length in the *Railroad Gazette* of November 20, 1891. The present decision of the Supreme Court does not annul previous decisions of the courts to the effect that owners of abutting property are entitled to compensation for such detriment as results to them from such a change of use. Since the date of the discussion reported in the *Railroad Gazette* above referred to, another property of great value has obtained vested rights upon the surface of Broadway, the double-track cable road, a very costly structure which is to be undermined by the new railway. The Commissioners have doubtless assured themselves that their four-track structure can be tunnelled successfully under the cable road and sidewalks without detriment to the same, and by a flat-topped heading. The experience even with circular tunnels is not such as to remove all doubts of settlement and a flat-topped heading under such circumstances is more experimental than a circular one. Wishing the enterprise the utmost success which the whole public is longing for, we still are of opinion that the Supreme Court have only helped them over the first of a series of difficulties which are before them.

THE first and most difficult section of the proposed waterway from Chicago to the Mississippi was let in various contracts on June 29. The amounts totaled up to $10,696,755. The contracting parties are Messrs. McArthur Brothers, Agnew & Co., E. D. Smith & Co., Mason, Hoge & Co., the McCormick Construction Co., and Alfred Harley. The channel is largely through rock and will serve the twofold purpose of diluting the Chicago sewage and a ship-canal for future commerce between the Lakes and the Mississippi. It will have a width at bottom of 160 feet and

a uniform depth of 19 feet, a gradient of five inches to the mile and a capacity of 600,000 cubic feet per minute. The Suez canal can be compared with it as regards navigable capacity, but not being designed as a discharging channel and being in fact a tidal water, the other data are not homologous. The Suez canal has a bottom width of 72 feet, just sufficient for one large steamer. It is in fact a "single-track" canal with "turnouts"; the Chicago canal will be "double track." The Suez canal has a top width of 197 feet, the depth in center being 26 feet or 7 feet more than that of the Chicago canal. The Amsterdam or Ymuiden ship canal has a bottom width of 89 feet, top width of 197 feet and depth of 23 feet, or 4 feet more than that of the Chicago canal, but it is also a one-horse canal. The superior dimensions of the Chicago canal were not so much demanded in the interests of navigation as in those of sewage disposal, the law demanding as it does a water supply for diluting Chicago's present and future excreta to the enormous amount of 600,000 cubic feet per minute. The position of the present work is neither the beginning nor the end of the programme of the Sanitary Commission. It is a stretch of fourteen miles of heavy cutting across what is called the Chicago divide or "height of land." It commences at a village called Willow Springs, twenty miles from Chicago Court House, close to the present Illinois and Michigan canal and runs in a southwesterly direction to Lockport, a town three miles from Joliet. The total length of cutting will be fourteen miles, the maximum depth in rock about 35 feet and in clay about the same. The faces of the rock cutting will be taken out plumb and smooth with channelling machines and the excavations will all be run to spoil on acquired lands. The earth cutting will be supported by retaining walls and the excavations go to form levees.

The Sanitary Board have shown considerable boldness in thus diving right into the heart of the difficulty which is before them. They have only acted after long and careful study of the whole question and have before them voluminous and exhaustive reports of experts. Perhaps the ablest exponent of the views of the Sanitary Board has been Mr. L. E. Cooley, now a member of the Board of Trustees and formerly Chief Engineer. The chief engineer now is Mr. Benezette Williams, and the chief assistant engineer Mr. J. C. Des Granges.

The difficulties which are before this great enterprise are serious, but the end in view is worthy of all the money that it is proposed to put into it. If it were only undertaken as a waterway project, it is grand enough to evoke the enthusiasm of the nation. Its aspect, however, as a great sewer has not merely robbed the poet of a theme but it has stirred the indignation of the district Government engineer, Captain Marshall, who has been strenuously opposing the application of Chicago for Government grants in aid of the enterprise, considering as he does that to do so would be to apply Federal money to municipal purposes. Chicago has therefore to handle the matter herself. With regard to the difficulties, the first is the lowering of the lakes by the abstraction of so large a volume of water. This matter has received very close study, and the result has been to show that no positive detriment will result to the navigation of the Detroit river or any other of the points where deep water is hard to get. In the second place, the addition of so large a volume of water to the Illinois river will doubtless affect the low-lying lands of the Illinois basin to some extent. Many of the farmers are now crying out against the Government for having dammed the river in several places, rendering their lands water-logged. The Sanitary Board are of opinion from their investigations and calculations that when these dams are removed, and the bed of the river improved, the river will obtain by scour a greater depth than it has at present, and at the same time a lower surface level so that the lands will be less water-logged than before. They do not fail, however, to appreciate the difficulty with floods, and no doubt the present season affords them an object lesson upon the subject.

They propose in the first place a cut at Bowmanville, in North Chicago, which

will carry off flood waters from the Desplaines river to the Lake, and so to prevent them from going down the Illinois river as at present. If, however, in spite of all their precautions, the floods should destroy the bottom lands of the Illinois river, Chicago will have to buy them up, and the Sanitary Board estimate those lands at so low a value as not to form an insuperable barrier to the enterprise. The next difficulty is the entrance into Chicago. It has not been determined yet where the channel will enter the lake, nor whether one or more cuts will be made. The question is one which involves several of the most important interests. The real estate which will have to be devoted to the fresh cuts will require a great deal of negotiation. One proposal for the intake channel is between the World's Fair grounds and the Calumet, another is at Bridgeport, somewhere near 39th street. The former would be on cheap land and the latter on very expensive property but more convenient for receiving the sewage. The north cut proposed at Bowmanville is not for an inlet but a spillway to keep the floodwaters of the Desplaines river from getting into the canal. These cuts will, in the second place, affect the transportation problem. The present harbor entrance, narrow and with low banks, has been a barrier to rapid transit on account of the swing bridges which obstruct also the navigation. The programme of the Sanitary board includes the entire filling up of this present harbor entrance, the creation of industrial properties on its site and the facilitation of rapid transit across the new cuts by means of tunnels. Seeing that every street must have its tunnel which will have to be about 1500 feet long including approaches, in order to make one crossing of the same capacity as a present street, the cost will be about $1500 per lineal foot or $2,250,000 per street. These figures are taken from the present prices at which the cheapest and most efficient method of tunnelling, that of the "Beach" or "Greathead' system, is being contracted for. It is true that the "May" tunnel was estimated to cost only $1,500,000, but the method of construction advocated was not one upon which reliable estimates can be made. Even upon a sanguine estimate these tunnels in such number would run into a huge pile of money. In the third place the scheme must, like any other systematic scheme, to a great extent revolutionize the present subdelivery of merchandise with the so-called markets of Chicago which are little more than usurpations of the sidewalks, but which have caused the erection of a class of buildings suitable only for that purpose. In the fourth place, when all these things are done, the Chicago river minus its present harbor entrance will remain, as now, an open sewer. Its grade and consequent transporting power will be improved; the floodwaters of the Desplaines river will no longer carry out the sewage to the cribs in the lake whence the people draw their drinking-water; but an open sewer it will remain. It may prove, furthermore, that on the annual record the river will contain more sewage than before. The spring freshets, although they carry out sewage from the river to an extent which pollutes the water-supply and are in that sense dangerous to the city, are on the other hand an effectual natural flushing system to the Chicago river. When this is done away, and the diluting stream supplied in South Chicago, it is possible that the sewage will have to be continually dredged away from the bottom of the stream to preserve the city from epidemic.

It is hardly to be expected that Chicago will utimately or indeed long be contented to have an open sewer of this magnitude through its center. The only way to make a complete job will be to stop all the sewers from debouching into the river, and to construct a complete main sewer system which will, as in the great cities of Europe, transport the sewage to a point such as Bridgeport, where it can be pumped into the drainage waterway. The bill for this piece of work will probably run to twenty or thirty millions.

In conclusion we must not be understood to undervalue the work which has just been authorized by the Chicago Drainage Board. It is a bold plunge into a scheme which has many ramifications,

and will involve a most prodigious expenditure—an expenditure which may too affect materially the cost of living. There are two great laws which operate upon the development of cities, the one is the centripetal force of *business going where business is*. The contrary or centrifugal force is that of *business going where business is cheapest done*. Cities reach their zenith when their development has so increased in costliness that living and trading has become more expense than that of smaller centers. In American cities, especially where primary conditions have to be revolutionized in order to pass from adolescence to maturity, capital is not always forthcoming for the outlay. Smaller cities then reap the benefit, and so fresh trade centers are established. Sewage disposal in Chicago is only one factor in an immense problem, the reorganization of all her municipal works. The future development depends upon how much useful work of an anticipative as well as present benefit can be accomplished within the borrowing powers of the city upon a basis which will not interfere with cheap residence and cheap trading as regulated by fees simple, rates, taxes and harbor dues.

THE frequent references in the engineering press to new methods of laying out transition curves is an indication that the easing of the shocks to rolling-stock of steam railways is becoming more a subject of general interest. In contrast with this is the supineness of street-railways towards the same question. Certainly where very high speeds are attained and derailment would be always attended with danger to life and limb, transition curves are of greater importance, but from another point of view, namely, that of economic advantage, the comparative importance is greater in street-railways. The practical objection raised to them is that if a curve becomes deformed or requires renewal, the ordinary tracklayer is apt to put in what one of them termed "somethink of a parabowler," and as the man knew as much as a cow of conic sections, the curve was unique. These difficulties vanish with the adoption of proper system and the furnishing of drawings and templets for renewals. Spirals for street-railways are, with the advent of mechanical traction and the highest speeds consistent with safety, becoming every year more important. The radii cannot be increased but the speed limit is in the hands of the motor-man, unchecked by the equine reluctance to whisk the ordinary horse-car round a corner. The company protects its cars from derailment upon sharp curves by means of guard-rails, but cannot prevent its passengers from the unpleasant swing and jolt when the cars turn a square corner at full speed, nor avoid wear and tear to the car wheels and axles from the sudden cross-strain.

With regard to joints, a company in Chicago is just putting down a trial mile of electrically-welded rail. The variations in length arising from unequal temperature between the head and the base of the rail will be taken up by strain in the material which will possibly attain as much as five tons per square inch. Such strain will of course in itself produce wear but it is doubtful whether it will be as great as that of the ordinary joint. The bad joint condemns the whole rail. The electrically-welded rail will wear uniformly, and if properly pounded will be prevented from buckling under strain. A mile is rather a long stretch for a first experiment and even if successful it might be found preferable to make joints at every block, not for expansion but for facility in renewal. The application of the continuous rail to steam railways would be much more difficult, but the continuous longitudinal metallic support might render it practicable.

IN this department in July the *Wergeland* was spoken of as the first steamer to arrive at Chicago "bearing an old-country flag." We are pleased to hear from Dr. Stockwell, of Messrs. Parke Davis & Co., of Detroit, that some six years ago the steamship *Rosedale* brought Portland cement from England to Chicago by the same route as the *Wergeland*. We are further pleased to receive his indorsement of our views as to the importance of the development of this waterway by improvement of the St. Lawrence canals.

# MINING AND METALLURGY.

*Conducted by Albert Williams, Jr.*

LAST YEAR 358 new iron and coal companies were incorporated, with an authorized capital of $133,471,830, and 1219 new gold and silver and other mining companies, with a nominal capitalization of $1,034,602,900. What the record will be for this year is beyond guessing, but for gold and silver mining companies the totals undoubtedly will be much higher. Of the making of corporations there is no end. The opening of new districts, especially in Colorado, has given rise to the formation of a swarm of stock companies, articles of incorporation having been filed at the rate of several hundred a month ever since the beginning of the year. It is hardly necessary to explain that the capitalization stated is largely in the air, hundreds of thousands or millions often figuring where only a few hundreds or thousands have been paid in; and when a stock certificate is inscribed "full-paid and non-assessable" the expression may often be understood as a legal fiction or to signify that part of the full payment is represented by a conveyance of property on a paper basis. Few mining companies are capitalized at less than $200,000; from this they range up to $1,000,000 or $5,000,000 and sometimes $10,000,000—but the figure is usually meaningless.

Capital is needed to develop and work most mines before they can be put on a paying footing. To form a company and sell stock is a perfectly legitimate and straightforward method of securing the money needed, besides being about the only way in which small investors have a chance to take interests in mining. Unfortunately for the small investors, however, they are usually incapable of judging of the merits of a mining "proposition," nor have they the means of finding out, open to capitalists, through the employment of disinterested professional advice. What little information they have comes through the prospectuses and advertisements of the sellers, and the "fixed" reports of the sellers' experts. The man who risks only a few dollars does not care much for information; for he probably regards all kinds of mining as a wild gamble, and does not realize that in some modern forms of the game there is no gamble at all, but a dead-sure "cinch." There was a time, not so long ago, when speculation in mining shares, especially those of the Comstock, was carried to such a pitch that stock certificates were handled like so many counters and not regarded as representing shares in so much ground and machinery. In a game conducted in that spirit it was not especially important to know whether the property represented by the pieces of paper had any value or not, so long as the certificates passed current and went on see-sawing up and down in price. But that sort of thing has about come to an end—at least for the present. It may come into vogue again, after people's memories are dulled. Nowadays the mining proposition is invariably put forward as an investment, and as such it must be rated, for there is practically no market for wildcat stocks for speculative purposes in the exchanges. To make the investment a plausible one a new and improved device (as the patent men would call it) has been introduced; namely, to pay small but regular (unearned) dividends at the rate of 12 or 18 per cent. a year, or a cent to a cent and a half monthly on the dollar, on the small amount of outstanding stock, until sufficient appearance of stability is given it, the manipulators paying the "dividends" out of receipts from further sales of stock. When the shares have all been sold, or as many of them as can be, dividends cease, there being no occasion for more bait being wasted; the stock is left to take care of itself and speedily drops out of sight, the property is attached and the deal is at an end. That

is the sort of mining proposition that is bringing discredit upon a noble industry. Compared with the old-time speculative idea, it is as bunco is to faro; not an open game with a remote prospect of winning, but a despicably mean and small steal. There are some other innovations, more or less ingenious, in the present methods of placing insecurities, which would require a book for full description.

It must not be supposed that all or nearly all of the new mining companies are to be set down as frauds. Almost all of the biggest and best mines, the ones which pay real dividends or give promise of doing so, are owned by companies. Many of these are close corporations and never list their stock on any exchange; indeed have none to sell. Then there are other companies which, not having inside backing, have to offer part of their shares to the public in order to raise money to carry on work, for there are very few mines which pay from the start. But it is not in human nature to give something for nothing, or very much for very little; and when a company advertises its stock for sale it invites scrutiny and should receive it. There will have been several thousand new companies launched this year. Some will be very profitable—to shareholders; some profitable—to insiders and promoters; and some will fall flat. Just what proportion of each kind there will be is an interesting but difficult question.

SEVENTEEN of our mining states, and almost all European countries, have laws designed to protect the miner against the peculiar and ever-present dangers to which he is exposed. Coupled with these laws is a more or less efficient system of mine inspection, for their enforcement and also leading to modifications in their provisions and to progressive amelioration of the dangers of mining. It is in the older coal mining states, as Pennsylvania, Ohio, Kentucky and some others, that governmental supervision and restriction have been developed to the highest point; and abroad the most painstaking attention is given to the subject in all the most highly civilized countries. The question frequently comes up, particularly when some unusually destructive disaster has startled and aroused public interest, to what extent these legal precautionary measures are operative in warding off or lessening the dangers of mining. This is one of the few questions that can be put to the direct and generally admitted conclusive test of statistics, for the records in some states and foreign countries are kept with great precision and extend over a long enough series of years to afford reliable averages. Yet there are some few persons whose hostility to paternalism in government (which feeling is doubtless well founded so far as general principles are concerned) renders them captious as to legislative and official intervention in this direction as well as in others, and disapproving the main idea they question the utility of its application in this instance. Granting that statistics do show a progressive diminution of accidents, they would ascribe the improvement rather to increased knowledge, skill and public spirit than to compulsion. Without entering into an extended argument, it is worth while to note that the greatest gain has been made in localities where laws and inspection are most stringent; that the progress has been made in the face of steadily-increased difficulties brought about by changes in the conditions of mining; and that in more than one instance a change in the law or the introduction of a new one is marked by an immediate and unmistakable reflex in the statistics. Furthermore, the statistics are silent as to what might have happened in the absence of restriction, nor do they show how many unnoticed escapes are due to it. And we do not often hear operators or miners complaining about unnecessary hardships being introduced by legal restrictions; for if a law is oppressive or found to work badly in practice there is a ready recourse in annulling or amending it. The laws differ in different places, and in all they should admit of a certain amount of flexibility. Thus to rigidly enforce a hard-and-fast rule that every mine, whatever its size and character, must have two exits, would involve needless expense in many small mines; or to apply an arbitrary re-

quirement for ventilation might be out of place in non-fiery mines—both of these illustrative regulations being well intended and eminently suited to other conditions. But while there may be local differences in laws, inconsistencies and a want of finality that calls for repeated tinkering, we know that the best thought of the most competent men is devoted to the subject and that the whole mining profession is ever awake to its importance. It would be a sad commentary on human intelligence if the net result were not a betterment. As to this we have something definite in the testimony of cold figures, from an array of statistics for several foreign countries and some of our own states.

FATALITIES in Belgian coal mines have been steadily decreased in proportion to the output and working force, from a death rate of 2.982 per 1000 in 1851–60 to 2.605 in the next decade, 2.45 in 1871–80, and 2.13 in 1881–90. The gain is not large, but its regularity is significant.

The French coal-mining statistics give still better results. In 1851–60 the death rate per 1000 was 3.4; it was 2.96 in the next decade, 2.219 in the next, and only 1.57 from 1881 to 1890.

The Prussian statistics are on their face far less satisfactory, the death rate in coal mines per 1000 running 2.054, 2.864, 2.896 and 3.142 for the last four decades. Some explanation of this may be found in the number of destructive explosions singly involving large loss of life; but that seems hardly sufficient. It is only fair to quote the records as they stand.

Much attention has been paid in Great Britain to the averting of coal-mining accidents, and of all foreign countries that presents the most gratifying record of improvement. In 1852–60 the ratio (which had previously been higher) of fatal accidents per 1000 employés was 4.07; in 1861–70 it had been reduced to 3.329; between 1871 and 1880 to 2.354, and in the last decade it was 1 949. The British statistics are the more valuable because of the care with which they have been kept and the enormous output and large force of men represented, the annual production having trebled between 1852–60 and 1881–90, the number of employés meanwhile doubling from a quarter million to over half a million. Notwithstanding the deplorable loss of life (it being computed that upwards of 11,000 persons have been killed by coal-mining explosions in that country during Queen Victoria's reign), a distinct proof of the beneficial effect of mine inspection is given, and the *Colliery Guardian* asserts that "had not the working system been improved as production advanced the deaths would have been doubled or trebled within the last twenty years." To this might be added that we have no means of knowing precisely what the death rate would be if there were no regulation at all, for exact statistics only go with inspection.

IN 1891 there were 911 separate fatal accidents in the British coal mines, involving the death of 979 persons; a ratio of one fatal accident to each 712 persons employed, and one life lost in every 662, or a death rate of 1.51 per 1000. This is the best showing yet attained, and the amelioration is ascribed to the better working of the present coal mines regulation act. Comparing the figures with those of former periods, *Iron* says:

"Under the act of 1850, which expired in 1855, the annual ratio was one death in every 233 persons employed. During the five years 1856-60 in which the act of 1855 remained in force, the average ratio of mortality was one in 258. This further improved under the next act, which was in force from 1861 to 1872, when the ratio was one in 312. The act of 1872 embraced coal, stratified ironstone, shale, and fireclay mines, and was in force up to 1887. Under it the average ratio of deaths still further decreased to one in 466. Last year, the proportion was one in 662. This marked and continuous improvement cannot be regarded as anything but highly satisfactory."

The improvement was due to the large decrease in the mortality occasioned by fire-damp explosions. While there was in fact one more separate accident of this kind than in 1890, the deaths resulting were only 51 last year, as against 290 in 1890.

WHAT the average value of a coal-miner's

life in the United States is, as measured by the tonnage raised to the life lost, cannot be stated with exactness in the absence of complete statistics for the whole country, but the common saying that for every 200,000 tons mined a life is lost is probably not so very far from the truth. It is claimed that, of the large operators in Pennsylvania, the Parrish Coal Co., at Plymouth, mined the greatest number of tons to the life lost in 1891, the output being 362,867 tons to one death, out of 579 men and boys employed about the mines. No matter how the money value of a life is computed, whether on the basis of the gross value of the coal at the mines or the net profit represented, the ratio is still a distressing one. Expressed in dollars and cents, the miner's life goes very cheap.

A more encouraging view of the situation is had by taking into account the steady improvement. Thus for England the *Colliery Guardian*, reviewing the records, asserts that "the occupation of the miner is now more than twice as safe as it was at the commencement of the inspection." For Pennsylvania, the *Colliery Engineer* claims that "there is no doubt that two tons of coal are mined now per life lost in the mines to one ton mined before the mining law was passed." For Kentucky, Inspector Norwood shows a reduction of fatalities from one to every 330 persons employed underground in 1888 to one for every 405 in 1889 and one for every 604 in 1890.

AN interesting comparison between dangerous occupations has been made by the *Colliery Engineer*. Taking the statistics of the Inter-State Commerce Commission for the year ending June 30, 1890 (the latest available), it finds that with 530,999 men employed on the railways of the United States there were in that year 2451 fatal accidents, or a death rate of 4.615 per 1000, and 22,396 non-fatal accidents, or 42 per 1000. These figures are placed alongside corresponding statistics for the anthracite and bituminous coal mines of Pennsylvania, which show that with 183,604 men employed there were 524 fatal accidents, or a death rate of 2.854 per 1000, and 1388 non-fatal accidents, or 7.56 per 1000. Summing up, it concludes, while disclaiming any intention of deprecating the well understood risks of mining, and insisting upon more careful management and better display of judgment on the part of the miner himself:

"These figures speak very strongly. They tell us that a man employed about a railroad has [nearly] twice as much chance of being killed as a man about a Pennsylvania colliery, and the collieries of Pennsylvania are as fiery as any in the world. They also show that if a man is liable to be injured in a mine once a year, his brother working on the railroad system of America is equally liable to accident once every seventy-five days."

The *Colliery Engineer* very justly considers it a duty to point out the mistaken popular idea about the relative dangers of coal-mining as compared with those in other callings, in defense of a large army of officials, both inspectors and mine managers, who are striving to the best of their ability to combat these dangers and to master the many subjects allied to the theory of their profession; and remarks that in face of the newly discovered and hitherto unsuspected danger from coal dust they have a big job on hand. It adds a deserved tribute to the increased intelligence exhibited by the miners themselves, as shown by the decrease in the number of accidents in mines in recent years.

MINE inspection and enforcement of law cannot do everything. Better ventilation, double means of egress, safety devices for hoisting machinery, and some other details, can be insisted on and secured; but personal carelessness lies beyond reach of official remedies. There is a prevalent impression that (in coal mining) explosions are the accidents most to be dreaded. That this is not so, Mr. C. J. Norwood, State Inspector of Mines for Kentucky, took pains to point out in a masterly essay published in this magazine [Vol. II., No. 2, November, 1891] when he said: "More casualties, in the even course of [coal] mining are chargeable to falls of roof and of coal than perhaps to all other causes combined." In support of this statement, the percentages of different classes of ac-

cidents in Pennsylvania coal mines for six years ending in 1889 show: explosions, 12.9 per cent.; falls, 64.2 per cent.; other causes, 22.8 per cent. But turning to the foreign statistics we find that while more than twice as many lives are lost by falling coal and caves as by explosions, the proportion of accidents from miscellaneous causes is about the same as those due to falls. In different localities the varying conditions of course alter the proportions of the several classes of casualties.

IT would be important to ascertain, if it were possible, in just what proportion of accidents the existence or absence of official inspection has effect; and still more so to be able to separate preventable accidents from those in which ordinary prudence and foresight seem unavailing. There is no way of getting at definite figures to throw light on these points. But while opinions differ somewhat and generalizations are uncertain, because particular cases involve varying sets of conditions and must be judged separately, the general drift of expert opinion is toward classing the larger number as due to individual carelessness. If this view is correct, the responsibility is largely shifted from the inspectors and operators to the miners. The system of inspection may be sound and the inspectors vigilant and conscientious; the operators may provide the most approved equipment and work the mines by the most prudent methods—yet all this may not avail. As to whether the fatalities resulting from falls of roof and sides and of undercut coal, and accidents from various causes in the shafts, etc., are to be regarded as generally avoidable, *Iron* thinks that "such accidents are essentially of a preventable nature and are almost always the consequence of carelessness or recklessness on the part of the men themselves;" and in another connection that journal affirms that "looking at these figures [the British statistics for 1891] generally, it may be safely said that if they prove anything at all, they demonstrate that our [British] miners hold their lives to a very great extent in their own hands." Or, to put it in other words, in this direction mine inspection and operators' precautions have done about all that can be expected of them. On the other hand Mr. Norwood, who is certainly good authority, says: "Very many of the accidents due to falls of top are entirely unavoidable, owing to the treacherous character of the overlying shales." This of course is a local irregularity, and Mr. Norwood goes on to say: "But a large proportion of accidents caused by falls of top and of coal are due to procrastination in setting props and to a failure to support the overhanging block of coal when reaching under to extend the 'mining.'" Machine mining lessens this latter danger. Safety in the handling of explosives rests almost entirely with the men, though rules for blasting may have some effect. Explosions of fire-damp might be rated as preventable (by thorough ventilation and avoidance of naked lights), were it not for the sudden inflows of gas which come without warning in mines supposed not to be fiery; while the study of dust explosions has evolved enough plans for prevention, one would suppose, to bring them under control in one way or another. Apart from accidents proper, the insidious and cumulative injury caused by breathing air unduly charged with carbonic acid is something to be guarded against, now that attention is being directed to its importance. This affects the physical condition and the general death rate of the coal-mining communities, but is not susceptible to statistical analysis.

IN a recent issue of the *Engineering and Mining Journal* Dr. R. W. Raymond very pertinently asks:

"Are great catastrophes more frequent and more terrible in this generation than in any preceding one, or is it merely because we hear of disasters in all parts of the world so quickly and so fully through the telegraph and the press, that every morning's paper brings us a catalogue of horrors?"

Answering his own question, Dr. Raymond observes that undoubtedly there is much truth in the latter proposition. As he says, "we thrill with pity over the victims of the day before in China, in Mauritius, or in distant parts of our own wide land, the far-

thest corner of which is brought nearer to us than Philadelphia was to New York within the lifetime of men yet living." But further he calls attention to a peculiar class of dangers, created by our modern improvements, and to a large extent ignored by our people, until ruin and death enforce too late the lesson of prudence:

"To this class belong our mining operations, which are steadily increasing both in the depth of the mines and in the number of the workmen exposed in each mine to various dangers. * * * This theme * * * deserves not one, but many, separate articles, enforcing the all-important truth that the methods and precautions which suffice for small and shallow mines are not enough for deeper and larger ones. The recent disaster at Przibram is an awful warning of the danger of erecting, even under the most skillful direction and careful inspection, a vast structure of underground timbering, so open throughout that, once kindled, it will burn like the fuel in a gigantic stove."

The factor of depth is more important in metalliferous mining than in coal mining, but it applies also to the latter in a certain degree, as new and deeper seams are opened and old mines are extended on the dip. Accidents in metal mining (which will not be discussed now) in part differ in character from those in coal-mining, and on the whole are less destructive to life. But the point is well taken that, for both kinds of mining, the heavier production and larger scale of operations with the attendant increase in the working force, in individual mining enterprises, at the present day vastly augment the dangers from wholesale catastrophes in single cases. That there are not more of them, and worse ones, is all the more credit to both officials and miners, the efficacy of whose skill and preventive measures certainly more than keeps pace with the constantly growing difficulties.

AMONG the suggestions evoked by the recent disaster on Oil Creek, Pa., is a demand that the petroleum tanks should be buried. This might not wholly do away with the risk, but would certainly lessen it. The plan has been broached before, but its revival is timely now while the effect of the late calamity is still fresh in the public mind. Not only in the oil-producing regions, but wherever petroleum is stored and refined, does danger attend the storage of this highly inflammable substance in tanks placed in positions from which leakage, collapse of the tanks or supports, and fires however originated, may in a moment send forth a flood of oil that, if not already ignited, is liable to catch fire on the least provocation. Water does not stop it, but acts as a carrier to spread the conflagration, and ordinary means of fire-extinguishing are unavailing. It has been pointed out that the storage of quantities of petroleum in high tanks along the water fronts of the larger cities is an ever-present menace to the shipping, wharves and buildings; and it is possible to conceive of a more appalling disaster than that of Oil City and Titusville being occasioned in this way without warning. The idea that lightning has an "affinity" for petroleum, which has received a certain currency of late, is of course absurd; but the iron of the tanks surely does present an attractive mark for lightning. There are however enough other modes in which ignition is likely to happen to render the danger an imminent one.

To place the tanks underground would involve a large additional outlay in construction and also increase running expenses for pumping in handling the oil. It would be asking a great deal to require the oil companies to reconstruct their present tank systems, though prudence might dictate even this in extreme cases; but something might at least be done to check their future extension in places where danger threatens surrounding life and property. In the open country and in situations where accidents to the tanks would not endanger the neighborhood, high tanks would still be built, being preferable on the score of economy and convenience. It would be easy to determine where sunken reservoirs would be better. If it is going too far to invoke the aid of law, the insurance underwriters by concerted action in regard to this kind of exposure could perhaps bring about a change, where most required.

# MACHINE-SHOP NOTES.

*Conducted by Albert D. Pentz.*

AN engine lathe fitted with an inside face plate will be found to be a valuable accessory in every shop where much tool work is to be done. Take the ordinary large face plate of the lathe ; make a cast-iron disk the same size as that face plate and about 5 per cent. of the diameter in thickness—that is, one inch thick to twenty inches in diameter—and carefully drill three or four holes at regular intervals through both near the circumference, they being clamped together for this purpose. Into these holes in the face plate fit studs, or posts, to extend outward perhaps eight inches on their bodies in addition to the shanks that are fitted to this plate. These shanks may be one inch in diameter, long enough to pass through the plate and be fastened behind by nuts and washers. The body of the studs may be two inches in diameter and they must be drilled and tapped in the outer ends. These studs on their outer ends must be faced carefully in position, so that the inner face of the disk shall run dead true when it is fastened in place. This disk is secured to the studs by carefully fitted cap screws and dowel pins and its circumference is turned to exact truth after it is attached to place. Then, in the middle of this disk a suitably-sized hole is to be bored to work through. Within this inside face plate all manner of boring and facing operations may be done. The work may partly be attached to the original face plate, to the disk, an intermediate angle plate, or all of these. The saving in time of rigging up, and the rigidity of hold will be found to be great and will be appreciated by both the workman and the manager. With this fixture there seldom is need of the angle plate and when a counterweight is needed it can be attached precisely where it will do its work best.

COMMENTING on the fact that an advertisement for a boy wanted in an office at $2.50 per week was answered by a hundred letters, the editor of a trade journal who should know better asks "Why is this?" and then answers himself that it is because members of trade-unions will not teach any more boys their trades and as a consequence they are all driven to other means of support. It is true that trade-unions do not want to increase largely the number of mechanics because their ranks now are so full that a large percentage of skilled workmen cannot get work to do at all, and many others not at living wages. Therefore they seek to preserve their means of livelihood from further destructive competition as far as possible. This wrong is not connected with these unions to a greater degree than it is with owners of trade journals, with railroad corporations, or with any other business or association of men. Suppose it should be demanded of that editor and newspaper owner that he should instruct parties who propose to compete with him at once in every detail of his business, both in the counting-room and on the editorial desk. Would he do it? Would the railroad company gratuitously assist a parallel line to equip? No! These questions indicate the reasons why boys are not more generally taught trades by the members of unions. Of course it is all wrong, but is it a greater wrong in the machine-shop than elsewhere?

A LITTLE clear study will convince every engineer that diametral pitch is the best theoretical as well as the simplest practical scheme for calculating the sizes of gears. It is obvious that circumferential pitch is only another term for the diametral pitch because the ratio 3.1416 between these two elements of the circle is a constant. What is usually called the circular pitch, however, if it is not pro-

portionate to diametral pitch, is the chordal pitch, because it is usually laid out as a polygon within the pitch-line by the dividers. This is ordinarily the most practical method to indicate the distance between teeth for pattern-makers who do not, as a rule, have mechanical means for spacing the circle proportionately to the length of its circumference; and they are thus obliged to inscribe within the pitch-line a polygon with double as many sides as the number of teeth they require. The fact in relation to diametrical pitch that disturbs a person taking a superficial view of the pitch problem, is that a space or tooth on a diametral pinion having eight teeth has a chord about .025 shorter than a corresponding chord on a gear of the same pitch which has one hundred teeth; and gears having other numbers of teeth vary in a proportionate degree. This at first looks as if the action of that pinion with eight teeth in that gear with one hundred teeth would be decidedly bad. But it must be borne in mind that gear wheels should not move differentially as polygons but regularly as circles. The pitch-lines of two meshed gears are in actual *material* contact but an instant of motion as each tooth of one gear passes through one of the spaces in the other. Consequently they are not more the driving points than other contiguous points of the blades of the teeth. Again, the chord of the pitch-line of the immeshed tooth can never be coincident with the chord of the pitch-line of the space it occupies. Hence the pitch-chord of a tooth cannot be an item of any importance in designing it. The whole matter is made clear when it is stated that the driven wheel must move with as regular a motion as the driver has, that is, the pitch-line in each must move forward an equal number of the same units of motion in each unit of time; and the blades of the teeth on each gear should be so shaped that they acting on the pitch-line of the teeth in the other gear shall give that result. This necessitates that the length of the the pitch-line should always be exactly proportionate to the quantity of teeth so that the pitch-arc in each tooth and space shall be of the same length in one gear of the same pitch as in another. Hence, the pitch-line being a circle, it follows that the quantity of teeth will also be proportionate to the length of the diameter if they are proportionate to the length of the circumference.

SOMETIMES an improved means supersedes an old practice, part of which old practice is superior to the corresponding part of the new one. Thus the use of emery cloth has largely superseded the use of the pointed pine stick charged with oil and emery for lathe polishing because iron and steel, because the emery cloth is handier. Now while this emery cloth is an admirable help in lathe polishing, it has limits and defects. Its limits are the impracticability of operating it within sharp angles, or deep within any angle—and the tendency to brighten high elevations to a greater degree than lower ones. Its defects are its tendency to scour off sharp corners, to remove too much material by abrasion where it should only burnish; and by filling up with metal and scratching the work. Added to these is the temptation to the workman to neglect to finish with oil and thus invite rust. With the old-fashioned soft pine stick dipped in mixed oil and emery, and served vigorously with elbow grease and a reasonable speed, a polish can be got that cannot be approached either for color or for uniformity by the use of emery cloth.

JOHN RUSKIN may be a great authority in architecture and the scenic arts, but he seems to take a narrow view of progress. It is true, as he asserts, that there is considerable misery apparent among the class of persons who live by writing begging-letters, and I believe such misery to be a fact real and grievous. Furthermore I admit that the tendencies of progress are such as to increase the misery these persons suffer, and will so augment them that they must either starve or seek work. Modern society is rapidly outgrowing a toleration of the petty courts that rich men once gathered about their persons and residences; so that many professional henchmen, retainers, hangers-on, diners-out, and

others who have the instincts of servants and the manners of snobs have now no regular places to feed or patrons to clothe them. To this class may be added persons and families whose traditions and teachings forbid them to work, but who must be fed and clothed. Now one of the habits common to all the persons indicated above, whose pride and inclinations forbid them to labor and whose circumstances do not afford them the means to live, is that of begging by letter. These facts do not indicate that the conditions of life are worse in the main than before, but that one class of persons is being evolved out of existence by the industrial trend of present progress. On the whole it is a hopeful expression indicating the high level toward which civilization is rising.

IF a machinist be given the remnant of a broken gear that contains the hub and two teeth only, he should be able to determine every element of the whole wheel. The pitch (diametral) may be found very easily by one of three methods: First, if the gear be properly made the thickness of the point of a tooth will indicate the pitch. Thus an 8 P. tooth is or should be very close, one-eighth of an inch thick at the point; and other pitches of correctly made gears obey the same rule of the comparative equality of their points to the signatures of their pitches. Hence those fractions of the whole circumference which remain on the points of all the teeth of a gear, after it is cut, would if added together approximately equal in length the pitch diameter. Second, the depth of the space from the circumference in a gear is or should be about 2.16 of the pitch, thus a 10 P. gear will have spaces about 2.16 inches deep and a 6 P. about 3.6 inches deep. Divide 2.16 by the full depth of the space in inches and the result should approximately be the pitch. Third and most reliable method, measure a chord from the side of one tooth, across that tooth and across the space to a corresponding point on the next tooth, on the pitch-line as nearly as can be guessed, and one-third of this chord will be approximately the diametral pitch. A fractional pitch is not used as a rule except with very coarse teeth; and therefore when the approximate pitch is found the true pitch can be determined with practical certainty. Thus with the first rule, the point of a tooth may be considerably less than .12″ or more than .13″ and there should be no reasonable doubt that in either case the gear is 8 P. Therefore, with the second rule, the space may be anywhere between .21″ and .225″ and always indicate 10 P. And hence with the third rule, the length of the chord may be between .49″ and .53″ and the inspector may be positive that it is 6 P. and not 5½ P. nor 6½ P. When, therefore, in the case of the broken fragment of a gear, the pitch is thus obtained, then all that is problematical is found. If the hub is present the radius can easily be got, and when both the radius and the pitch are known the getting of the diameter and whole number of teeth are of the simplest kind of problems.

THE designer of tools must be correct in his deductions or his work is a failure. In no department of human industry is it so necessary to be right as in the initial creation of pieces of metal that are to be assembled together as a machine to do a specific operation. In an essay, or an argument, it is only necessary to convince the reasoning faculties of an audience or an individual that theories are right; or the better ones. This is also true of the drawings for machinery, which often will satisfy the most critical of inspectors while the machine made from them may absolutely fail to operate, and in itself will convict both the designer and the critic. A machine either works as designed or fails, as a fact; logic cannot help it. The difficulties, however, do not exculpate the engineer who attempts to design a tool and fails. His failure is just as much a black eye for a new creation as for the adaptation of a well-known device for a new use so similar to the old one that there are but few chances in the problem for the design to fail. The designer must question mentally until the thing thinks out clear. Then he must question on paper

until it looks clear, and finally he must experiment in some shape until it actually is clear. Every mechanical problem a man works out helps him on each succeeding one; but the problems that the other man works out do not help in the same degree, and many problems personally worked out is what is meant by practice. Knowledge of mathematics is a necessary item in a designer's equipment, but it must be so placed in his mind that it can readily be applied to practical problems of phases differing from those used as illustrations at school. I know men who are good mathematicians provided they are not deployed from problems similar to those in their text-books; but when they are required to make new applications of their knowledge or materially to modify it to suit an abstruse problem, they are helpless as the first schoolboy in this item: He, being asked "Six girls times six oranges are how many of which?" answered "Er-thirty-six girls—er-er-oh-" "Next boy!" "Thirty-six oranges if the six girls hadn't et any of 'em." There was the timber for an engineer in that last boy.

DE GREE recently attended the commencement exercises of the school that graduated him. On securing an interview with a professor who had taken an interest in him during his school years, he explained his difficulties in practical experience and asked advice, thus:

"You see, professor, it was the next May after I left here before I got a chance of any kind, and father had become so impatient that he was about to put me on the road as a brakeman when I got an introduction to Mr. Blunt and went to work for him at 12 cents an hour, beginning at 7 A. M. and stopping at 6 P. M. At the end of a year I had the princely salary of fifty dollars a month, and Mr. Blunt kept me hard at work calculating sections and areas to withstand stated strains and to hold stated contents, drawing harmonious outlines, and in everything figuring out the last ounce of superfluous metal, to his order. But when I make a suggestion to convince him that I am not a blockhead, he sits down on me so hard that I am often tempted to resign and try to get a more congenial place."

"You have been there more than four years. Does he not give you more than the sum you mentioned now?"

"Oh, yes, I get a $100 a month now."

"Do you not have any title or position? I have heard you were his manager."

"I carry out his instructions but if I attempt to do any actual management he lays me out."

"My dear boy, you have a very busy father and a very indulgent mother, so that you have been getting your first taste of what American boys are most in need of—discipline. Now, if you can persuade Mr. Blunt to take my boy Fred. who is just graduated, and make a man of him you will do me a greater favor than I have ever been able to do for you."

THE true inventor has no regard for dogma; he believes he sees light ahead and moves toward it. It may be that what he sees is an ignis fatuus or a chimera, but he insists on discovering that for himself and he is satisfied with no theories. I recently talked with a perpetual-motion man and tried to dissuade him, being confident it would be easy to convince so intelligent a person that his scheme was not possible. But he rose above my dogmas in an instant by showing that the whole solar system is a perpetual-motion device, moving without assignable cause and not varying an instant of comparative time within the period of its recorded history. I thought of Galileo, and stopped.

IF you will examine a polished cast iron surface with a strong glass you will notice that it has not a continuous metallic appearance; it will look like a web of bright metal filled in with a darker gray substance. This darker filling may be partly graphite and partly iron in an imperfectly metallic state. Now it is supposed, in soldering to a surface of this kind, that the molten metal will adhere to only the skeleton of bright iron and have no union whatever with the filling, and that this diminished surface makes the soldering difficult and makes the joint weak after it is soldered.

# COMMENT & CRITICISM.

### The Cape Hatteras Problem.

IN the July number of this magazine Captain J. W. Walters has set forth very clearly some of the difficulties in the way of erecting a lighthouse on the shifting sand reefs off Cape Hatteras, and has proposed a plan for carrying out the project. Although the "Dutch have captured Holland" with willow mattresses, it would be by no means safe to predict that similar structures would withstand the effect of wave action at the Diamond Shoal reef. Captain Walters is eminently correct in his views as to the value of a breakwater for the protection of the plant and foundation during construction, and the important uses to which brush mattresses may be put in submarine structure, but to attempt the construction of the entire breakwater of such material would be attended with a risk that few engineers familiar with such construction would care to take.

In planning structures to withstand the forces of the sea, it must be borne in mind that ocean waves on entering shallow water become waves of translation and strike any obstruction in their way with tremendous force. Experiments made at various places show this striking force to be from one to three-and-a-half tons per square foot of exposed surface. Off Cape Hatteras it would be at least two tons per square foot, or a total pressure of more than the specific weight of the structure. In 1873, during a violent storm at Wick, Scotland, the waves removed a monolithic mass of concrete, weighing 2600 tons, from its position in the breakwater, and carried it to the leeward of the works. When we consider that brush-work would not have one-tenth the specific weight of a concrete wall it is very evident that such a structure would not resist such forces, even during a moderate storm.

Captain Walters's brush cribs for his breakwater would be approximately 125 feet long, 75 feet wide, and 30 feet high, each of which he expects would, with its own buoyancy, carry about 533 tons of ballast without sinking. Half that amonnt of ballast would sink the crib as soon as the brush became watersoaked. Another serious drawback to the chances of permanency for such a structure would be the destructive action of the teredo, which in a few months would so eat away the wood of every stick of brush that the upper works of the cribs would go to pieces from the outward pressure of the ballast. At the mouths of sediment-bearing streams mattress-work silts up so rapidly that the teredo can do but little damage, but in the open sea such action is not sufficiently rapid to prevent the worm from destroying the works.

It is to be hoped that before another attempt is made to carry out this project the Lighthouse Board will cause a thorough examination to be made of the physical characteristics of the location. It may be argued that the competing contractors should make their own examinations, but that seems hardly just, for then only the successful bidder would get any return for the labor and expense, whereas if the examination is made by the Government only one is necessary and serves for all who may care to bid.

GEORGE Y. WISNER.

Detroit, July 6, 1892.

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### "Truth Seeker" and "A Southern Engineer."

IN the June number of this magazine "Truth Seeker" runs counter to me on the question of the discharge over Niagara, and also on Mississippi navigation. I will answer him on both points, and at the same time pay my respects to "A Southern Engineer," who writes of "Impending Disaster on the Mississippi." The depth of Niagara at the crest of the Horseshoe Fall was sounded in 1827 by the ship *Michigan*, when she went over, measuring twenty feet at that point. It may be less or more elsewhere. I think it would not

be impossible to take soundings all over the crest and would like to undertake the contract. "Truth Seeker" makes the discharge more than I do; most authorities make it less. My point was that the abstraction of a large body of water at Chicago from Lake Michigan would produce a sensible effect upon the flow over the Niagara crest, and "Truth Seeker" does not contravene that statement.

With regard to the point which "Truth Seeker" makes of the coincidence of a "tear" in the Mississippi at the time of the publication of my article, he would argue that it was best to let it have its fling. I think the American people will paraphrase Solomon and say, "Go to the beaver, thou sluggard, and dam it up again."

It may be just as well that an exceptionally rainy season should occur at the time when this question is being driven home upon the public mind and public purse. Americans do not scare by wet weather like the ancients by signs in the heavens. They will, however, realize still more forcibly the necessity of building their fluvial improvements on the Mississippi "from the mouth to the source" rather than "from the source to the mouth"— by this is meant an order not of time but of system. Whatever the Government does at the final outlet should be done with regard to the future rectification of the whole channel and its effect upon flood level. There will be causes tending both to elevate and to depress that level in the system of rectification. Then also they must take into account the effect of denudation of the forests. If the natural "sponge" of this country is allowed to be removed in order to get cheap lumber, the water will flow down as it does in India, and a speedy devastation of the valleys will take the place of the magnificent fluvial civilization extending from the lakes to the Gulf. *One generation has no right to deprive the next of the means of livelihood.*

At the beginning of June *Bradstreet's* gave the aggregate loss as $32,000,000 and records showed that 15,000 families were left destitute. This loss does not represent an extraordinary disaster, but what may be expected to come with increasing frequency and augmented horror. "Truth Seeker" talks of the $8,000,000 spent on the Mississippi outlet and adds that the United States is not made of money; but why should the unfortunate people who live on the "Great American Bottom" have to lose $32,000,000 and bear all the misery when they are united for better and for worse to the whole empire?

The remedy proposed by "a Southern Engineer" is an attempt to improve the stream for navigation by removing the bends which cause great deviations in transit and at the same time to furnish overflow channels by means of the bayous. His plan is founded on the idea that the current of a river loses its scouring force by the elevation of its banks and so he condemns in a wholesale manner the building of dikes as "rudimentary engineering." But the foundation of his argument is incorrect. It is doubtless the fact that the elevation of the banks of a river is found accompanied by the raising of its bed and consequently the reduction of its scouring force, but this raising of the banks has not raised the bed; it is the raising of the bed which has entailed the raising of the banks in order to prevent inundation. But what has raised the bed? It is an action which is known as "retrogression of levels" or it might perhaps be better termed "the degradation of bed." Here I would explain that in my allusion to rectification as the replacing of sharp corners by easy curves, I did not mean a process such as "A Southern Engineer" recommends of making artificial "cut-offs," but only of smoothing the asperities of the concave sides of the bends by easier curves protected by fascines and similar methods of training to prevent erosion. It is the cut-offs which the Mississippi has made for itself during floods, leaving all manner of annular lakes which have produced the retrogression of levels entailing the raising of banks. To use electrical language, the river "short-circuits" itself carrying a great mass of material to be deposited lower down. Wherever a stream has an abnormal hydraulic gradient it takes up a mass of material where it is valuable, and

deposits it where it is detrimental, thus entailing the building of banks at the lower reaches. The objective point in rectification is the hydraulic gradient or bed of the stream. When a slope has been obtained of such uniformity that the river will not keep on robbing Peter to pay Paul, the river will take care of itself.

The upper reach being at a gradient capable of producing erosion, makes the lower reach at a flatter gradient into a silting basin, until the dikes have to be raised. The dikes do not cause the loss of scouring force, but the scouring and consequent silting lower down require the banks to be raised. There is of course a further elevation of adjacent lands which was demonstrated as early as 1853 by Charles Ellet. This is due to deposit of silt during overflow. The first thing that appears advisable for treating the problem as a whole, is the construction of working models of the whole river such as were first employed by Professor Osborne Reynolds, for the analysis of tidal action on the Mersey. The results of these experiments were described in the May number of THE ENGINEERING MAGAZINE.

The Mississippi has received the study of the best engineers, especially during floods, and the result has been to show the small value of relief channels or reservoirs in the bayous. Outlets to the Gulf below Red river may be found necessary but the main principle for the improvement of the whole river is to obtain such a uniformity of gradient that as little as possible of Uncle Sam's territory will be stolen by the "Father of Waters" and that what is stolen will be carried through to the Gulf where it can do no harm.

The Mississippi is a vast aggregation of problems, but they all demand solution under one simple law, not primarily in order to produce deep-water navigation, but to prevent the river from continuing its process of self-destruction and devastation of the adjacent country. It cannot be treated tender-handed or it will laugh at the puny fetters that seek to bind it, but it may be mastered at far less cost than the loss which it will produce if let alone, and its proper treatment for the purpose of self-preservation will at the same time make it into an ocean highway from New Orleans to Chicago.

T. GRAHAM GRIBBLE.

Chicago, June 2, 1892.

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### A Protest Against Cremation.

I AM surprised to see THE ENGINEERING MAGAZINE give place to a profusely illustrated article on Cremation. Cremation is simply the revival of a pagan custom condemned long since by the Church of God. "All men shall rise again *in their own bodies*." The veneration of the remains of the dead rests to a great extent on the belief in the resurrection. This is particularly true of the usage of burial, which from the earliest ages of the Church took the place of the pagan custom of cremation. This is manifest from the existence of Christian cemeteries (resting-places of the dead) and from the testimony of the fathers who defend the Christian usage of burial as the older and better manner of disposing of the dead. Hence the Holy Catholic Church in our day has justly declared cremation to be unlawful.

RUSSELL THAYER,
M. Am. Soc. C. E.

Philadelphia, July 3, 1892.

# CURRENT TECHNICAL LITERATURE.

TO THE READER.—This catalogue is compiled from the technical periodicals of the United States, England and France. If you were to subscribe only for those of most importance, it would cost you over $500.00 a year. If you were to undertake to read them, you would do nothing else from year's end to year's end. To subscribe for THE ENGINEERING MAGAZINE and get the benefit of this catalogue costs you but $3 a year. To glance over those departments of the catalogue in which you are chiefly interested, and decide which of the articles listed are of real value to you, requires but fifteen minutes of your time each month. If you have taken the precaution to purchase a stock of our coupons, it will take you but ten minutes more to fill out, say a dozen, and enclose them in an envelope to THE ENGINEERING MAGAZINE COMPANY, WORLD BUILDING, NEW YORK. No letter-writing is required. A stamped envelope does the work. In return you will receive the dozen articles desired, though they may be published at a dozen different points in the world.

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In the body of the index the initials of the papers quoted are given, and these can be readily identified by the alphabetical list of periodicals below. Other abbreviations are: Ill=Illustrated; w=words.

## *THE AMERICAN PRESS.*

A S .....Age of Steel. *w.* $3. St. Louis.
A An.... American Analyst. *f.* $1 per year. N. Y.
AA.....American Architect. *w.* $6. Boston.
A Ar.....American Artisan. *w.* $2. Chicago.
A C J....Am. Chemical Journal. *b-m.* $4. Baltimore.
A D.....American Druggist. *m.* $1.50. New York.
A G L J..Am. Gas Light Journal. *w.* $3. New York.
A G.....Am. Geologist. *m.* $3.50. Minneapolis.
A J Phar.Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A..American Journal of Railway Appliances. *m.* $2 per year. New York.
A M .....American Machinist. *w.* $3. New York.
A M & I W.American Manufacturer and Iron World. *w.* $4 per year. Pittsburg.
A A A....Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A H.....Annals of Hygiene. *m.* $2 per year. Phila.
A E .....Architectural Era. *m.* $3. N. Y.
A R.....Architectural Record. *q.* $1. New York.
A Rev....Architectural Review. *s-q.* $5. Boston.
A & B....Architecture and Building. *w.* $6 N. Y.
A.....Arena. *m.* $5 per year. Boston.
A & N J..Army and Navy Journal. *w.* $6. New York.
A & N R..Army and Navy Register. *w.* $3 per year. Washington.
At M.....Atlantic Monthly. *m.* $4 per year. Boston.
B J C....Boston Journal of Commerce. *w.* $3 per year. Boston.
B & W...Builder and Woodworker. *m.* $1. N. Y.
B P .....Bulletin of Pharmacy. *m.* $1. Detroit.
C A.....Calif. Architect. *m.* $3. San Francisco.
C E N....Canadian Electrical News. *m.* $1 per year. Toronto.
C & B... Carpentry and Building. *m.* $1. New York.
C M.....Century Magazine. *m.* $4 per year. N. Y.
Ch.....Chautauquan. *m.* $2. Meadville, Pa.
C E. .....Colliery Engineer. *m.* $2. Scranton, Pa.
C.....Compass. *m.* $2 per year. New York.
Cos.....Cosmopolitan. *m.* $3 per year. New York.
Cr.....Crank. *m.* $1.25 per year. Ithaca, N. Y.
D E.....Domestic Engineering. *m.* $1. Chicago.
D J.....Dralnage Journal. *m.* $1. Indianapolis.
D Jour. .Druggists' Journal. *m.* $1. Chicago.
E A.....Electrical Age. *w.* $3 per year. New York.
E E N Y..Electrical Engineer. *w.* $3 per year. N. Y.
E R N Y..Electrical Review. *w.* $3 per year. N. Y.
E W.....Electrical World. *w.* $3 per year. N. Y.
E & R ...Electricity and Railroading. *m.* $1 per year. Boston.
Eng .....Engineer. *s-m.* $2 per year. New York.
E M J....Engineering and Mining Journal. *w.* $4 per year. New York.
E Mag ...Engineering Magazine. *m.* $3. New York.
E M.....Engineering Mechanics. *m.* $2. Phila.
E N.....Engineering News. *w.* $5 per year. N. Y.
F & M R..Financial and Mining Record. *w.* $3. N.Y.
F W.....Fire and Water. *w.* $3 per year. N. Y.
F .....Forum. *m.* $5 per year. New York.
G & F....Garden and Forest. *w.* $4 per year. N.Y.
G G M...Goldthwaite's Geographical Magazine. *m.* $2 per year. N.Y.
G R.....Good Roads. *m.* $2 per year. N. Y.
I A.....Inland Architect. *m.* $5 per year. Chicago.
I R W...India Rubber World. *m.* $3 per year. N.Y.
I S F....Industry. *m.* $2 per year. San Francisco.
I Age....Inventive Age. *s-m.* $1. Washington.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A C S..Journal of the American Chemical Society. *m.* $5 per year. N. Y.
J A E S..Journal of the Association of Engineering Societies. *m.* $3 per year. Chicago.
J F I.....Journal of the Franklin Institute. *m.* $5 per year. Philadelphia.
J M S I..Journal of the Military Service Institution. *b-m.* $4 per year. Governor's Island, N. Y. H.
J N E W..Journal of the N. E. Waterworks Association. *q.* $2. New London, Conn.
L M.....Leather Manufacturer. *m.* $3. N. Y.
L E.....Locomotive Engineering. *m.* $2. N. Y.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
M R.....Manufacturer's Record. *w.* $4. Baltimore.
M N.....Mechanical News. *s-m.* $1.50. New York.
M & El...Mechanic and Electrician. *w.* $2 per year. St. Louis.
Met W....Metal Worker. *w.* $2 per year. N. Y.
Min .....Minerals. *m.* $1 per year. N. Y.
M S P....Mining and Scientific Press. *w.* $3 per year. San Francisco, Cal.
M S R....Mining and Scientific Review. *w.* $2 per year. Denver.
M I T....Mining Industry and Tradesman. *w.* $3 per year. Denver.
Misc.....Miscellaneous.
N B .....National Builder. *m.* $3. Chicago.
N C B...National Car Builder. *m.* $2. N. Y.
N A R...North American Review. *m.* $5. N. Y
N W.....Northwestern Architect. *m.* $3. Minneapolis.
O M.....Overland Monthly. *m.* $3 per year. San Francisco.
P L .....Pacific Lumberman, Contractor, and Electrician. *w.* $3. San Francisco.
P.....Paving and Municipal Engineering. *m.* $1 per year. Indianapolis.
P Era....Pharmaceutical Era. *s-m.* $2. Detroit.
P R .....Pharmaceutical Record. *s-m.* $1.50. N. Y.
P S N....Popular Science News. *m.* $1. Boston.
P S.....Power-Steam. *m.* $1 per year. N. Y.
P E. .....Practical Electricity. *f.* $2 per year. Boston.
P A .....Progressive Age. *w.* $3. New York.
R A E J..Railroad and Engineering Journal. *m.* $3 per year. New York.
R C J....Railroad Car Journal. *m.* $1 per year. N.Y.
R G.....Railroad Gazette. *w.* $4.20 per year. N. Y.
R A.....Railway Age. *w.* $4 per year. Chicago
R M M...Railway Master Mechanic. *m.* $1. Chicago.
R R.....Railway Review. *w.* $4 per year. Chicago.

R P.....Registered Pharmacist. *w.* $1. Chicago.
R & T...Roofer and Tinner. *m.* $1 per year, N. Y.
S V.....Safety Valve. *m.* $1 per year. N. Y.
San.....Sanitarian. *m.* $4 per year. Brooklyn.
S Era... Sanitary Era. *m.* $1 per year. N. Y.
S P.....Sanitary Plumber. *s-m.* $1. N. Y.
S M Q.. .School of Mines Quarterly. $2. N. Y.
Sc.....Science. *w.* $3.50 per year. New York.
Sea.....Seaboard. *w.* $2 per year. N. Y.
S A.....Southern Architect. *m.* $1. Atlanta.
S E.....Stationary Engineer. *w.* $2. Chicago.
S.....Stone. *m.* $2 per year. Indianapolis, Ind.
S R G....Street Railway Gazette. *w.* $5. Chicago.
S R N....Street Railway News. *w.* $3. N. Y.
T Q.....Technology Quarterly. $2. Boston.
T A I E E.Transactions American Institute of Electrical Engineers. *m.* $5 per year. N. Y.
W E.....Western Electrician. *w.* $3. Chicago.

## THE FOREIGN PRESS.

C T J....Chemical Trade Journal. *w.* 12*s.* 6*d.* per year, post-paid. Manchester, Eng.
C G.....Colliery Guardian. *w.* 27*s.* 6*d.* per year, post-paid. London.
C R.....Contemporary Review. *m.* $4.50 per year, New York. London.
D.....Discovery. *w.* 8*s.* 8*d.*, post-paid. London.
E E L....Electrical Engineer. *w.* 17*s.* 4*d.* per year. post-paid. London.
E P.....Electrical Plant. *m.* 6*s.* per year, post-paid. London.
E R L....Electrical Review. *w.* 21*s.* 8*d.* per year, post-paid. London.
El.....Electrician. *w.* 24*s.* post-paid. London.
El P.....Electricien. *w.* 25 *fr.* post-paid. Paris.
E L.....Electricity. *w.* 6*s.* 6*d.*, post-paid. London.
Eng L....Engineer. *w.* 36*s.*, post-paid. London.
E.....Engineering. *w.* 36*s.*, post-paid. London.
F R.....Fortnightly Review. *m.* $4.50 per year. New York. London.
G E M...Gas Engineers' Magazine. *m.* 6*s.* 6*d.* per year, post-paid. Birmingham, Eng.
G W.....Gas World. *w.* 13*s.*, post-paid. London.
G C.....Génie Civil. *w.* 45 *fr.*, post-paid. Paris.
I C B....Illustrated Carpenter and Builder. *w.* 8*s.* 8*d.* per year, post-paid. London.
I E.....Indian Engineering. *w.* Rs. 18 per year, postage extra. Calcutta.
I L.....Industries. *w.* 32*s.*, post-paid. London.
Inv.....Invention. *w.* 28*s.*, post-paid. London.
I.....Iron. *w.* 30*s.* per year, post-paid. London.
J G L....Journal of Gas Lighting. London.
K.....Knowledge. *m.* 6*s.*, post-paid. London.
M.....Machinery. *m.* 9*s.*, post-paid. London.
M E.....Marine Engineer. *m.* 7*s.* 6*d.* per year, post-paid. London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* per year, post-paid. London.
M I.....Moniteur Industriel. 3 times a week. 40 *fr.* per year, post-paid. Paris.
N C.....Nineteenth Century. *m.* $4.50 per year. New York. London.
P Eng...Practical Engineer. *w.* 10*s.* per year, post-paid. London.
R N.....Railway News. London.
R U M...Revue Universelle des Mines. *m.* 40 *fr.* per year, post-paid. Paris.
S R.....Sanitary Record. *m.* London.
W R.....Westminster Review. *m.* $4.50 per year. N. Y. London.

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*5323. Testing for Gas in Coal Mines. Professor Clowes (Ibid.) 2000 w.

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*5337. Observations on Petroleum in Eastern Europe and the Method of Drilling for It. I. Arthur W. Eastlake (Ibid.) 2700 w.

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4852. Practical Hints on House-Heating. III. Leicester Allen (Ibid.) 3000 w.

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*5159. Petroleum in the Suez Canal. Editorial (Eng L–June 24.) 800 w.

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*5363. Requirements of Rubber Coats for Miners. Albert Williams, Jr. (I R W–July 15.) 1250 w.

*5364. Impurities in Steam in Rubber-Curing. Robert Grimshaw (Ibid.) 1500 w.

# NEW BOOKS OF THE MONTH.

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Aldrich, Wilbur.=Farming Corporations. New York: W. Aldrich & Co. [12mo, cloth, 266 p., $1.]

American Railroad and Corporation Reports. A collection of the current decisions of the courts of last resort in the United States pertaining to the law of railroads, private and municipal corporations, etc. Chicago: E. B. Myers & Co. [8vo, sheep, 819 p., $4.50.]

Archimède.=Le Traité des Corps Flottants. Translated into French by Adrien Legrand. Paris: Gauthier-Villars et fils. [8vo, paper, 28 p., 1 *fr.*]

Barbier de Montault, X.=L'Architecture et la Décoration à l'Abbaye Cistercienne des Châtelliers, du Douzième au Dix-huitième Siècle. Poitiers: Roy & Cie. [8vo, paper, 55 p.]

Catalogue and Price List of Steam Specialties, Steam Traps, Pumps, and Pump Governors. Albany: Albany Steam Trap Co. [16mo, paper, 48 p., free.]

Cobb, A. G.=Earth Burial and Cremation. New York: Putnam. [12mo, cloth, 182 p., $1.]

Delahaye, P.=L'Année Electrique, ou Exposé Annuel des Travaux Scientifiques, des Inventions et des Principales Applications de l'Electricité à l'Industrie et aux Arts. Paris: Baudry & Cie. [18mo, 356 p.]

Descriptive Index of Current Engineering Literature, 1884–1891. Chicago: Association of Engineering Societies. [4to, cloth, 475 p.]

Dolbear, A. E.=Matter, Ether, and Motion: the factors and relations of physical science. Boston: Lee & Shepard. [12mo, cloth, 341 p., $1.75.]

Duthil, A. H.=Avant-projet du Chemin de Fer à Navires entre l'Océan et la Méditerranée par Richards - Bordeaux - Narbonne - Gruissan. Paris: Imprimerie Alcan-Lévy. [4to, paper, 25 p., 2 *fr.* 50*c.*]

Madamet, A.=Tiroirs et Distributeurs de Vapeur. Appareils de mise en marche et de changement de marche. Paris: Gauthier-Villars et fils. [16mo, paper, 149 p, 2 *fr.* 50*c.*]

Maimbressy, C. de.=La Photographie: matériel, atelier, laboratoire, devis approximatif, les opérations, les plaques, photographie instantanée, photographie à la lumière artificielle, agrandissements. Paris: Delarue. [16mo, paper, 180 p.]

Mémorial de l'Officier du Génie, ou Recueil de Mémoires, Expériences, Observations, et Procédés Généraux Propres à Perfectionner la Fortification et les Constructions Militaires. Paris: Gauthier-Villars & Fils. [8vo, paper, 599 p., 7 *fr.* 50*c.*]

Millar, C. C. Hoyer=Florida, South Carolina, and Canadian Phosphates: giving a complete account of their occurrence, methods and cost of production, quantities raised and commercial importance. New York: Scientific Publishing Co. [8vo, cloth, 223 p., $2.50.]

Moore, F. C.=Economical Fire-Resisting Construction. A treatise on building. New York: Continental Fire Insurance Co. [8vo, paper, 37 p., 12 plates, 25*c.*]

Munier, J.=Le Télégraphe Imprimeur Multiple. Paris: Carré. [8vo, paper, 78 p.]

Niewenglowski, G. H.=Notions Elémentaires de Photographie à l'Usage des Amateurs. Paris: G. H. Niewenglowski, 66 Boulevard Saint-Germain. [18mo, paper, 101 p., 1 *fr.*]

Piton-Bressant=Mélanges. Balistique et Artillerie; Sciences Historiques et Autres. Paris: Imprimérie Nationale. [8vo, paper, 334 p.]

Reference Directory of the Machine, Iron, Steel, and Metal Working Trades, Plumbers, Steam and Gas Fitters. Philadelphia: George Storey & Co. [4to, cloth or flexible leather, 431 p., $10.]

Report upon the Sewerage of the District of Columbia. Washington: Government Printing Office. [8vo, paper, 75 p.]

Sloane, T. O'Conor.=The Arithmetic of Electricity. A manual of electrical calculations by arithmetical methods. Including numerous rules, examples and tables in the field of practical electrical engineering and experimenting. Third edition, revised, New York: Henley. [12mo, cloth, 134 p., $1.]

Tison, F.=Hygiène, Ventilation, Chauffage, Air Intérieur Pur et Tempéré, Assainissement, Moyens Corrigeant les Nombreux et Habituels Défauts des Habitations et Autres Edifices pour Ecoles, Hospices, Casernes, et Habitations Privées, etc. Lille: Imprimérie Vitez-Gérard. [8vo, 56 p.]

Vautier, A.=Etude des Chemins de Fer Funiculaires. Paris: Baudry & Cie. [8vo, paper, 77 p.]

Voss, Wm.=Railway Car Construction. A work describing in detail and illustrating with scale-drawings the different varieties of American cars as now built. New York: R. M. Van Arsdale. [4to, cloth, 177 p.]

Weiss, G.=Technique d'Electro-Physiologie. Paris: Gauthiers-Villars & fils. [16mo, paper, 214 p., 2 *fr.* 50*c.*]

Wickersheimer, E.=Etude sur le Rachat des Chemins de Fer d'Orleans, de l'Ouest, de l'Est, et du Midi. Préface de Camille Pelletan. Paris: Chaix. [8vo, paper, 228 p.]